

Historic, Archive Document

Do not assume content reflects current
scientific knowledge, policies, or practices.

775.9
Ag 8

Do not list in B & A

A Preliminary Summary of

Progress and Plans

POTATO RESEARCH

of the United States Department of Agriculture
and
in cooperation with
State Agricultural Experiment Stations

Prepared for the Department's
POTATO RESEARCH AND MARKETING ADVISORY COMMITTEE

for its 17th Annual Meeting
Washington, D. C.

November 28-December 2, 1960

.....

. This progress report is primarily a tool for use by advisory com-
. mittee members in developing recommendations for present and future
. research programs and by USDA administrators for developing, coordi-
. nating, and evaluating research plans. Included in it are summaries
. of research done during the past year. Some are tentative results
. that have not been tested sufficiently to justify general release.
. Such findings, when adequately confirmed, will be released promptly
. through established channels. Because of this, the report is not
. intended for publication and should not be referred to in literature
. citations. Copies are distributed only to advisory committee members,
. research administrators, and others having special interest in the
. development of public agricultural research programs.
. .

. The report also lists publications of research results issued
. during the year. Current agricultural research findings are also
. reported in the monthly USDA publications, "Agricultural Research"
. and "Agricultural Marketing."
. .

.....

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C.

U. S. DEPT. OF AGRICULTURE
NATIONAL AGRICULTURAL LIBRARY

AUG 11 1964

C & R-PREP.

FUNCTIONS OF ADVISORY COMMITTEES

The Potato Committee is one of twenty-four commodity and functional committees of the U. S. Department of Agriculture established pursuant to Title III of the Research and Marketing Act of 1946. Functions of the members of these committees include:

1. Acquainting themselves with the problems of producers, processors, distributors, and consumers, and presenting them for committee consideration.
2. Reviewing the current research and marketing service programs of the Department and recommending adjustments, including terminations, in the current program in order that available funds, personnel, and facilities will be used on problems of greatest importance.
3. Recommending new work or expansion of current work and indicating relative priority of such recommendations, when the current program is insufficient to develop solutions for important problems.
4. Developing a better understanding of the nature and value of the agricultural research program, explaining it to interested groups and organizations and encouraging the wider and more rapid application of the findings of research.

The committees perform an important function in advising with respect to the development of the Department's research and marketing service programs. However, committee members recognize that the development of budgets and the implementation and administration of research and marketing programs are responsibilities of the Department.

A progress report similar to this one is prepared for each committee. The areas of the other twenty-three committees are:

Citrus and Subtropical Fruit	Livestock
Cotton and Cottonseed	Oilseeds and Peanut
Dairy	Poultry
Deciduous Fruit and Tree Nut	Refrigerated and Frozen Products
Economics	Rice
Farm Equipment and Structures	Sheep and Wool
Food and Nutrition	Soils, Water and Fertilizer
Food Distribution	Sugar
Forage, Feed and Seed	Tobacco
Forestry	Transportation
Grain	Vegetable
Home Economics	

This progress report was compiled under the leadership of Roy Magruder, Executive Secretary, Potato Research and Marketing Advisory Committee, Office of the Administrator, Agricultural Research Service, U. S. Department of Agriculture, Washington 25, D. C.

CODES TO DESIGNATE UNITS CONDUCTING RESEARCH

AGRICULTURAL RESEARCH SERVICE (ARS)

Farm Research Divisions

AE	. . . . .	Agricultural Engineering
ADP	. . . . .	Animal Disease and Parasite
AH	. . . . .	Animal Husbandry
CR	. . . . .	Crops
ENT	. . . . .	Entomology
FE	. . . . .	Farm Economics
SWC	. . . . .	Soil and Water Conservation

Utilization Research and Development Divisions

EU	. . . . .	Eastern
NU	. . . . .	Northern
SU	. . . . .	Southern
WU	. . . . .	Western

Home Economics Research Divisions

CH	. . . . .	Clothing and Housing
HHE	. . . . .	Household Economics
HN	. . . . .	Human Nutrition

AGRICULTURAL MARKETING SERVICE (AMS)

Economics Statistics Division

AEC	. . . . .	Agricultural Economics
AES	. . . . .	Agricultural Estimates

Marketing Research Divisions

MD	. . . . .	Market Development
ME	. . . . .	Marketing Economics
MQ	. . . . .	Market Quality
TF	. . . . .	Transportation and Facilities

FCS	FARMER COOPERATIVE SERVICE
-----	-----------	----------------------------

FAS	FOREIGN AGRICULTURAL SERVICE
-----	-----------	------------------------------

FOREST SERVICE (FS)

Forest Research Divisions

FDR	. . . . .	Forest Diseases
FER	. . . . .	Forest Economics
FFR	. . . . .	Forest Fire
FIR	. . . . .	Forest Insect
FMR	. . . . .	Forest Management
FPR	. . . . .	Forest Products Utilization
RMR	. . . . .	Range Management and Wildlife Habitat
WMR	. . . . .	Watershed Management

TABLE OF CONTENTS

	<u>Page</u>
I. FARM RESEARCH -----	1
A. Breeding and Genetics	
1. Introduction, Breeding, Genetics, and Evaluation -----	1
B. Physiology and Nutrition	
2. Fertilizers and Plant Response -----	5
C. Cultural Practices	
3. Potato Culture-----	5
4. Soil and Water Management and Conservation -----	6
D. Disease and Nematode Control	
5. Disease Control -----	8
6. Late Blight Epidemics-----	11
7. Nematode Control-----	12
E. Insect Control	
8. Insects Affecting Potatoes -----	12
F. Mechanization of Production and Harvesting	
9. Production and Harvesting Equipment -----	16
10. Pesticide Application Equipment-----	17
II. UTILIZATION RESEARCH -----	21
A. Chemical Composition and Physical Properties	
1. Chemical Constituents -----	21
2. Chemical Composition and Physical Properties Related to Texture -----	22
3. Antioxidants to Control Oxidative Deterioration of Dehydrated Potatoes -----	24
4. Control of Non-Enzymatic Browning in Dehydrated Potatoes -----	25
B. New and Improved Food Products and Processing Technology	
5. Improved Potato Products, Processes and Equipment -----	25
6. Deterioration During Processing -----	32
III. MARKETING RESEARCH -----	34
A. Market Potentials, Preferences and Development	
1. Consumer Discrimination and Preferences for Potato Products-----	34
2. Market Potentials for New and Improved Potato Products -----	34

TABLE OF CONTENTS (Cont.)

	<u>Page</u>
III. MARKETING RESEARCH (Cont.)	
B. Measurement and Evaluation of Market Quality	
3. Objective Measurement of Market Quality Factors ---	35
C. Product Protection During Marketing	
4. Postharvest Physiology and Storage -----	35
5. Postharvest Diseases -----	38
6. Maintaining Quality During Transit -----	38
D. Transportation, Storage and Packaging	
7. Improved Loading Methods for 50- and 100-pound Bags--	42
8. Packaging Potatoes at Point of Production-----	43
E. Equipment, Facilities, Methods and Firm Efficiency	
9. Improved Methods, Equipment, Plant Layout and Design in Handling, Packing and Storing Potatoes -----	44
F. Costs, Margins, and Organization of the Marketing System	
10. Marketing Costs and Margins for Potatoes -----	49
11. Competition in the Processed Potato Market -----	50
12. Changes in Methods of Marketing -----	50
G. Price, Supply and Consumption	
13. Price, Supply, Demand, and Outlook Analysis for Potatoes -----	51
H. Foreign Competition and Market Analysis	
14. Foreign Trade in Potatoes -----	52

I. FARM RESEARCH

A. Breeding and Genetics

1. INTRODUCTION, BREEDING, GENETICS, AND EVALUATION

CR

Problem: Develop and evaluate new and improved varieties of potatoes having high yield and quality, resistance to diseases and pests, and suitability for specific processes and uses; introduce and use foreign germ plasm to increase genetic base for potato improvement.

Program: This is a continuing long-term program of introduction of varieties and species for direct or breeding purposes, cytogenetic and genetic studies, applied breeding, selection, evaluation, and ultimate release of promising new kinds. Between 9 and 10 professional man-years per year of Federal work is devoted to this problem at Beltsville, Maryland; Presque Isle, Maine; Madison, Wisconsin; Greeley, Colorado; Prosser, Washington; Aberdeen, Idaho; Baton Rouge, Louisiana; and Weslaco, Texas. Cooperative work is also conducted with State agricultural experiment stations at 25 additional places.

Progress: Plant introduction and development. A total of 812 introductions of potatoes and closely related species were received during the year from Mexico and other foreign sources. Of these, 523 numbers were hybrid potato seedlings being returned to the United States after late blight screening by the Rockefeller Foundation in Mexico. Other materials in quarantine of special note include 27 European potato varieties from Bulgaria and numerous wild potatoes collected in South America by D. S. Correll. When released from quarantine, they will be sent to the U. S. Potato Introduction Station at Sturgeon Bay, Wisconsin.

Breeding. New Varieties. Redskin is a high yielding red variety with resistance to both late blight and scab. It was released jointly with the Texas Agricultural Experiment Station as a replacement for Red Pontiac, especially in Florida and Texas.

Anita, Bertita, Conchita are varieties named in Mexico. The parental material was sent to Mexico by the United States Department of Agriculture, and the self-pollinations were made in Mexico. The selections were made in the field at the Santa Elena Experiment Station, near Toluca, Mexico. The high degree of late blight resistance of these three varieties permits production of high yields of tubers even in unsprayed fields during the rainy season in Central Mexico.

Outstanding Seedlings. In the early-variety yield test B 4312-21, a red seedling with resistance to scab and late blight, yielded 935 bushels per acre. Seedling B 3563-2, a leafroll-resistant selection, tested in the Maine cooperative yield test, produced an average yield of 598 bushels per acre when grown in 4 locations within the

State. It was very high in total solids and judged one of the best in color, based on chipping and frying tests. Seedling B 3309-8 also yielded over 800 bushels per acre. It is a red selection that has good scab and late blight resistance and is being used extensively as a parent. Seedling B 3696-13, with a yield of 728 bushels per acre, is highly resistant to scab and late blight and immune from virus A. It was superior to Green Mountain in yield, total solids, and chipping quality. (Coop. Maine)

Quality Evaluation of Unreleased Seedlings: Of 75 varieties or seedlings tested, none produced chips or French fries of acceptable color when processed directly from 38° F. storage. Forty-nine made better (lighter) colored chips after storage and reconditioning for 38 days than they did when processed after harvest, and 18 made darker chips. Several seedlings, such as B 3516-11 and B 3453-2, which are excellent parents with commercial possibilities, produced excellent chips and French fries, superior to those of most of the check varieties. (Coop. Maine)

Scab Resistance. More than 1,000 clones were tested for scab resistance. About 18 percent were free of infection and many of these clones had resistance to other potato diseases.

Verticillium Wilt. About 1,500 selections from 115 family lines were tested for Verticillium wilt-resistance. Significant differences in resistance appeared among family lines. Fifteen seedlings and varieties were tested for resistance in replicated inoculated and non-inoculated plots on infested soil. The non-inoculated plots showed a lower incidence of wilt than the inoculated plots. Houma, X 792-94 and X 792-88 in that order, showed very high resistance to wilt. (Coop. Maine)

Golden Nematode. Approximately 2,314 selections segregating for golden nematode resistance were tested on Long Island. Forty-eight were rated as highly resistant. It appears that we have resistance to the root knot and tuber rot nematodes as well. (Coop. New York).

Late Blight. Many promising selections were screened for general field resistance in the field and for major gene type of inheritance in the greenhouse. Selections are available now that possess a high level of field resistance in combination with one or more major genes for late blight resistance.

Leafroll Resistance. Nearly 6,900 single-hill tubers from 15 crosses and 7 selfed lines, were tested for leafroll resistance. The resistant selections, B 3563-2, B 3390-13, B 4127-7 and B 3570-5, were rated as good or better than Katahdin and Kennebec for yield, total solids, and chip color. Several highly resistant selections have commercial promise.

Ring Rot Resistance. About 400 new 5-hill selections were screened for ring rot resistance in the field, in 1959. Also, 10 resistant seedlings and 4 standard varieties were compared for yielding ability, specific gravity, and chip color. (Coop. Maine)

Potato Cytogenetics. Investigations on the crossability among Solanum species and meiosis in species and interspecific hybrids were continued at Beltsville. Several clones of 7 tetraploid, 36 triploid, and 52 diploid hybrid combinations were studied. Meiosis was found to be regular in the diploid and tetraploid hybrids. Of 553 interspecific combinations among diploids attempted, 109 produced seed.

Studies of haploidy in the common potato were emphasized. One hundred ninety-eight F_1 families from matings of S. tuberosum haploids and 23 diploid species were grown. Most of the F_1 plants were vigorous, unusually so in certain progenies. The effect of certain selections of S. phureja used as pollinators on Merrimack to obtain haploids, was studied. Frequency of haploids produced varied significantly with pollinators. (Coop. Wisconsin)

Idaho. Over 550 clones were evaluated for maturity and Verticillium wilt-resistance. Many of these were also tested for resistance to Fusarium eumartii, scab, leafroll, virus X, and virus A. Many parents having resistance to one or more of the diseases were selected for future work. Several of the 12 selections for increase, made by the Potato Committee, were superior to the Russet Burbank in resistance to Verticillium wilt and in yielding ability. One of these, seedling A 501-13, produced 505 cwt. of U. S. #1 potatoes per acre with 22.7 percent solids compared to 218 cwt. of Russet Burbank with 20.9 percent solids. (Coop. Idaho)

Iowa. Increase plots for Iowa selections were established at Rhineland, Wisconsin, and 181 lines plus this year's single-hill selections, were indexed in Florida to eliminate virus, especially spindle tuber. Studies on heterosis in potatoes to determine superior tester stocks were continued. Once a suitable tester has been found, a program of selfing and test-crossing will follow. Studies of field resistance to the potato leafhopper and fleabeetle in progenies and tuber-bearing Solanum species were conducted. Resistance to each of the insect species is apparently due to independent mechanisms. Only occasionally have selections shown resistance to more than one of these insects. (Coop. Iowa)

Southern Region. The development of new varieties adapted to southern growing conditions with superior horticultural and disease-resistant characteristics was continued. Yield tests of about 30 seedlings and varieties were conducted at Port Sulfur, La., Fairhope, Ala., and Crossville, Tenn. Several selections seem promising. TL 6937, in preliminary tests, has produced long, white, smooth tubers and has shown considerable resistance to scab and late blight, and relatively high solids content. (Coop. Louisiana and Tennessee)

Texas. A total of 380 breeding lines were grown and evaluated at 5 locations: Lower Valley, Winter Garden Station, Crystal City, Brazos Valley, and Prairie View. Also, 20,000 seedlings were grown in the Lower Valley and at the Winter Garden Station. Replicated plots were set up to study insecticidal effects, seed spacing, and fertilizer rates

on seedling B 2368-4. This seedling, at a 12-inch spacing, with 600 pounds per acre of a 16-20-0 fertilizer, yielded 271 cwt. per acre. Many selections have been selected and retested in Texas for 3 years. Additional new red and white varieties well adapted to the growing areas in Texas and resistant to the common potato diseases should soon be available. (Coop. Texas)

Washington. Recent tests have shown that B 2759-5 and B 3820-14 have remained symptomless for leafroll and Verticillium wilt, when tested in this State. Approximately 8,500 single-hill seedlings were increased and 95 selections were made to be tested in the future for resistance to scab, leafroll, Verticillium wilt, and several viruses. Progress is being made in selecting long russet seedlings with resistance to one or more diseases just mentioned. State investigators are now in a position to evaluate improved selections developed in this program for cooking and processing qualities. (Coop. Washington)

Plans: Potato improvement is a long range program and work will continue along present lines and at substantially the present level. Increased emphasis will be placed upon development of varieties adapted for processing. Continued stress will be given to development of varieties with high quality, free from black spot and after-cooking darkening. New work is being initiated to produce varieties free from tuber-greening under artificial lights.

Exploration and introduction of potatoes will continue through correspondence and exchange. Recommendation from advisory committees, research agencies and related groups will provide the means of efficient planning to meet future research needs.

Publications: The National Potato-Breeding Report, 1959. R. V. Akeley and others. Potato, Onion and Root Crops Section and State Cooperators. (Multilithed)

Maine Potato Variety Trials for 1959. H. J. Murphy, M. J. Goven, A. E. Schark and P. T. Blood. Maine Agri. Exp. Sta. Misc. Publ. 638, Feb. 1960.

Erendira, a New Blight-Resistant Potato Variety for the Highlands of Central Mexico. J. S. Neiderhauser, R. W. Buck, and R. V. Akeley (Abst.) Amer. Pot. Jour. 36:300. 1959.

A Comparison of Pollen Behavior and Pollen-Tube Growth in Styles of Potato Flowers Grown on Cuttings with Those Remaining on the Plant. D. R. Bienz. (Abst.) Amer. Pot. Journ. 36: 292. 1959.

Hybrids of Solanum Tuberosum Haploids and the Tuber-bearing Species. R. W. Hougas and S. J. Peloquin. (Abst.) Amer. Pot. Jour. 36: 296. 1959.

Resistance to Infection by Mechanical Inoculation with Virus X in Potato. A. E. Kehr and J. C. Horton. (Abst.) Amer. Pot. Jour. 36: 296. 1959.

Haploidy in Solanum Tuberosum and in the Subspecies Andigena. S. J. Peloquin and R. W. Hougas. (Abst.) Amer. Pot. Jour. 36: 302. 1959.

Tawa: A New Early Potato Variety Resistant to Late Blight, Scab, and Immune from Latent Mosaic. C. E. Peterson and W. J. Hooker. Amer. Pot. Jour. 36: 267-274. 1959.

Yields, Specific Gravity, and Maturity of Potatoes. C. E. Cunningham, H. J. Murphy, M. J. Goven, and R. V. Akeley. Univ. of Maine Bul. 579, Feb. 1959.

Effects of Seed-Cutting Dates on Yields of Various Potato Varieties. R. V. Akeley. Amer. Pot. Jour. 36: 147-153, 1959.

Healing Precut Potato Seedpieces During Transit. H. W. Hruschka, W. L. Smith, Jr., H. V. Toko, and R. V. Akeley. Agr. Mktg. Serv., Mkt. Res. Div. Bul. AMS-334, 1959.

Effects of Seed Spacing and Fertilizer Rate on Field Performances of Potato Varieties and Financial Returns. G. V. C. Houghland and R. V. Akeley. Amer. Pot. Jour. 36: 227-234. 1959.

Late Blight Resistance of Selected Potato Seedlings Highly Resistant to Ring Rot. Reiner Bonde, R. V. Akeley, and Donald Merriam. Plt. Dis. Rptr. 43: 924-928. 1959.

Report of Variety and Nomenclature Committee. O. C. Turnquist, R. V. Akeley, J. C. Miller, and A. G. Tolaas (Chairman). Amer. Pot. Jour. 36: 416-418. 1959.

Decapitation and Genetic Markers as Related to Haploidy in Solanum Tuberosum. S. J. Peloquin and R. W. Hougas. European Pot. Jour. Vol. 2, No. 3, Sept. 1959.

Resistance of Potato to Infection by Mechanically Induced Virus X. A. E. Kehr and J. C. Horton. Amer. Pot. Jour. 37: 61-66. 1960.

B. Physiology and Nutrition

2. FERTILIZERS AND PLANT RESPONSE

CR

This work has been discontinued as recommended by the Potato Research and Marketing Advisory Committee. Fertilizer problems are essentially local problems and as such are primarily functions of the State Agricultural Experiment Stations.

3. POTATO CULTURE

CR

No research work was conducted on potato culture problems. As recommended by the Advisory Committee emphasis in potato research is being placed elsewhere.

4. SOIL AND WATER MANAGEMENT AND CONSERVATION

SWC

Problem: Potato growers are confronted with problems of devising methods of irrigation, prevention of soil and water losses through erosion and developing soil management and crop rotation systems under which potatoes can be grown economically.

Program: A continuing program of research on soil and water conservation carried on in potato-growing areas in cooperation with the State Experiment Stations in Maine, Washington, Idaho, Utah, and Montana and involving about 2 professional man-years annually.

Progress: Diffusion of gases in tubers. The adequacy of the supply of oxygen, ions, or water at root surfaces is determined by the demands of the plants. Oxygen demands of root tissues and capacity of the environment to supply those demands were evaluated. As temperature was increased, respiration rate of root cells was increased and oxygen demand was increased. It was assumed that oxygen could probably move through the external tissue of roots and that the latter might limit aeration. Evaluation of rates of diffusion of gases through potato tuber tissue indicated that adequate supplies of oxygen to meet respiration demands could only be supplied to the external 2 - 3 mm of tissue. These data suggest that aeration would be more critical with thick rooted plants than thin rooted plants unless the root surface failed to represent the true exterior of the root.

Infiltrometer studies. The influence of coarse material in Maine Caribou and Thorndike soils on infiltration, runoff and erosion was studied with the use of a laboratory infiltrometer which applied water at 2.5 inches per hour but with energy of impact appreciably less than that in natural rain of the same intensity. Various sized coarse particles were removed from both soils to determine the function of the coarse fraction. It should be of interest to potato growers to learn that there was a significant decrease in the rate of infiltration and likewise an increase in runoff as the particles which were longer than 12.7 mm were removed from both soils. The amount of soil in the runoff from the Caribou soil was found to be nearly proportional to the runoff. It also increased with runoff as the coarse fractions were removed from the Thorndike soil. Lack of coarse particles in these soils could increase the erosion hazard.

Nitrogen recovery. In a 6-year field study at Prosser, Washington, in which the first four crops (sorghum, beets, potatoes, sorghum) were fertilized with each of three nitrogen carriers up to rates of 160 pounds of nitrogen fertilization, the average nitrogen recovery was 82.9 percent of that applied. Overall, recovery was the same for all sources. Percentage recovery was greater the higher the rate of application. These experiments on nitrogen recovery involve the assumptions that nitrogen content of the soil does not change, which may not be true, but they do show the efficiency of nitrogen use for all practical purposes.

Irrigation efficiency. During the 1959 season, irrigation efficiency for each irrigation during the season was measured on two farms in the Escalante Valley of Utah representing two soil types. The water application efficiency is a ratio of the amount of water stored in root zone by an irrigation divided by the amount of water delivered to the field. The average irrigation efficiency for potatoes on one farm for 11 irrigations was 48 percent and on another farm for 13 irrigations it was 38 percent. Water distribution efficiency which is calculated by subtracting one from the ratio of the average numerical deviation from the average water stored to the average stored multiplied by 100 was 84 for potatoes. It is possible to have high distribution efficiency with low water application efficiency because deep percolation and runoff do not contribute to low distribution efficiency, but may improve them. Water-use efficiency is defined as the ratio of total water consumed to total water delivered to the farm which, in this case, amounts to the water pumped from wells. The total water consumed is based on results of previous consumptive use values, and therefore is an estimate. Using this procedure, water-use efficiency for potatoes was 47.7 percent on one farm, and on another farm it was 28.2 percent. Variation in infiltration over the season shows a definite need for irrigation systems which have flexibility incorporated in their design. It apparently is difficult to predict whether the next infiltration will be higher or lower than the last one. Under such circumstances the farmer is the determining factor in what level of irrigation efficiency can be obtained. However, the water control facilities and irrigation system must have flexibility to make efficient irrigation possible, and the irrigator must use this flexibility.

Residue management. Numerous studies have continued on methods of residue management for erosion control. At St. Anthony, Idaho, work with fall chiseling and other fall tillage operations indicates appreciable reduction of runoff and thereby reduced soil erosion from these practices where spring runoff occurs on frozen soils.

Salt tolerance. Salt tolerance of several vegetable and forage crops was evaluated in Virginia. Irrigation water of different levels of salinity was applied to spring crops of beans, potatoes, tomatoes and onions. Yields of all crops decreased with increased salinity with the following order of salt sensitivity: Beans > tomatoes > potatoes > onions.

Plans: Work will continue to develop winter soil cover following late potatoes and to determine the influences of mulches on soil temperature and on yield and quality of potatoes, to lessen soil erosion, and to improve the fertility status needed for sustained yields of potatoes.

Publications: Some Plant Nutrient Relationships in the Potato Crop Grown on a Calcareous Soil. Jay L. Haddock and Ray D. Jackson, Amer. Potato Jour. 36:2, 56-63, February 1959.

Growth and Nutrient Uptake of Russet Burbank Potatoes. Ray D. Jackson and Jay L. Haddock. Amer. Potato Jour. 36:1, 22-28. January 1959.

Occurrence and Transfer of a Biological Factor in Soil that Suppresses Potato Scab. J. D. Menzies. Phytopathology, 49:10, 648-652. Oct. 1959.

D. Disease and Nematode Control

5. DISEASE CONTROL

CR

Problem: Determine the nature of causal agents of diseases, how they infect, spread, carry-over, and better ways of diagnosing their presence; develop practical methods of avoiding or controlling diseases through breeding, crop and soil management, or other means including fungicides, bactericides, nematocides, and insecticides.

Program: A continuing long-term program involving primarily basic research on the nature of specific diseases of virus, fungus, and bacterial origins, the nature and behavior of the causal agents, methods of diagnosis, new methods of research. About 5 professional man-years per year of Federal work is devoted to this problem at Beltsville, Maryland; Greeley, Colorado; Madison, Wisconsin; Baton Rouge, Louisiana; and Presque Isle, Maine. Work with State experiment stations also is conducted at 12 other locations.

Potato Introductions: Ninety-nine new stocks were received in 1959 from foreign laboratories and through Solanum expeditions to Mexico and South America. Shipment of seeds and tubers were made during 1959 to 18 States and 13 foreign countries. The evaluation of the Solanum species has continued at an accelerated pace. The stocks are being screened for their reaction to virus A, virus X, virus Y, leafroll virus, spindle tuber virus, and Verticillium wilt. (Coop. Wisconsin)

Potato Diseases: Virus A. At Beltsville, Maryland, of 93 seedling varieties screened for immunity from virus A, 55 selections were graft-immune. Of 86 selections of Solanum tuberosum (S. andigenum), 15 were resistant to mechanical inoculation and 28 were highly resistant to graft inoculation. Selections in S. chacoense, S. demissum, S. hougasii, S. maglia, S. phureja, S. stoloniferum, and 8 species hybrids were found to be highly resistant to virus A.

Virus X: Of 1031 seedling varieties and 86 named varieties screened by mechanical inoculation for resistance to a virulent strain of virus X, 120 failed to become infected. Graft inoculations of 189 seedling selections of combinations of 13 susceptible parents were made to study the possibility that virus X immune progenies could be obtained by combining 2 susceptible parents. The tests are not complete. Of 86 selections of Solanum tuberosum (S. andigenum) 13 were highly resistant to graft inoculation. Selections in S. acaule, S. maglia, S. sucrense, and 1 species hybrid were highly resistant to virus X.

Parallel subinoculations from highly resistant plants grafted with virus X to indicator hosts Gomphrena glubosa and Datura stramonium indicated that D. stramonium is much more efficient in detecting virus X at low titres than is G. globosa.

Crimson clover (*Trifolium incarnatum* L.) has been found to be a systemic host for both the ringspot and yellow strains of virus X. The 2 varieties tested, Dixie and Chief, were both susceptible. (Coop. Wis.)

Virus F: At Madison, resistance to virus F has been found in self plants of the cross, Epicure X ln Solanum chacoense. Certain lines of S. chacoense, as well as species hybrids involving S. chacoense, were also found to be resistant. (Coop. Wis.)

Virus Y: Four hundred and fifty-six seedling varieties and 92 named varieties were screened for resistance to virus Y by aphid inoculation under field conditions and indexed in the greenhouse for susceptibility. Seventy-eight unnamed varieties and the named varieties Calrose, Conoga, Canso, Canus, Essex, Golden, Norland, Onaway, Red Beauty, Majestic, Pentland Ace, and Urgenta did not become infected. Selections from progenies of the following parental combinations proved resistant to virus Y: B 3443-6 x B 3418-10, B 3097-82 x B 3139-24, B 922-3 x 627-124 and B 2067-52 x ND 457-1. About 650 selections from selfed progenies of 9 parental lines were screened for field resistance to virus Y. The results indicated that progenies from parents such as Katahdin, ND 457-1, B 2067-52 and B 2068-23 possess a high degree of field resistance.

Immunity to graft-inoculation with virus Y was confirmed in Solanum stoloniferum and selections of S. chacoense, S. demissum, S. hougasii, and S. jamesii proved highly resistant to graft inoculation with the virus. No resistance to mechanical inoculation with virus Y was found in 86 selections of S. tuberosum (andigenum) or in 23 haploids of S. tuberosum.

Multiple resistance to viruses in Solanum species: Nine selections of S. tuberosum (andigena), one of S. maglia, and 2 species hybrids proved resistant to viruses A and X. Two selections of S. chacoense, 2 of S. hougasii, 3 of S. stoloniferum and 1 species hybrid proved resistant to viruses A and Y. No selection proved highly resistant to all three viruses.

Late blight: About 1,000 unnamed and 19 named varieties were evaluated for resistance to the race "O" of late blight in the greenhouse and for field resistance to the disease in the field. Eighty-eight foreign varieties were field-tested. The late blight race differentials were interplanted in the field plot to detect the appearance of races of the organism. About 500 unnamed and 3 named varieties were highly resistant to race "O" in the greenhouse. In the field, 376 unnamed varieties, 3 named domestic varieties and 18 foreign varieties were highly field-resistant to late blight. Races 1,2; 3; 4; 1,2; 1,3; 1,4 and 1,2,4 were present in the plot approximately 6 weeks after the inoculation with the "O" race.

Scab: At Presque Isle, Maine and Fargo, North Dakota, potatoes were planted to soil treated with 50 pounds (active) of Terraclor (PCNB) for the control of scab. Tubers were harvested and sent to Orono, Maine, Beltsville, Maryland and Fargo, North Dakota for flavor evaluation by the respective Home Economics departments. Tuber samples of varieties Cobbler, Red Pontiac, and Katahdin grown in soil treated with Terraclor were found to have a distinct off-flavor at each location tested.

Verticillium wilt: Crop rotation studies for the control of verticillium wilt of potatoes further substantiated the superiority of oats and millet over clover in a 3, 4, or 5-year rotation with potatoes for the control of the disease. Rotation was found essential to the control of the tuber "pinkeye" disease often associated with verticillium-infected potato plants.

Sixteen varieties were grown on soil heavily infested with the verticillium wilt organism to determine their relative resistance and to study seed tuber transmission of the organism. Houma, Russet Burbank, and S. 41956 were the most resistant and Plymouth, Merrimack, Kennebec, Cherokee, Pungo, and Cobbler were the most susceptible to the disease. Seed tuber transmission of the disease varied widely among the varieties, from 5 percent in Houma and Russet Burbank to 82 percent in Pungo.

Seed tubers of varieties highly resistant to verticillium wilt grown in infested soil were found to be surface-contaminated with the organism. Such infested tubers are possible sources for widespread distribution of the organism to wilt-free soils. Semesan Bel, Dithane Z-78, Phygon XL and Captan were used as seed treatments for the control of seed-borne inoculum of verticillium wilt. Only Semesan Bel materially reduced the incidence of wilt in plants grown from infected seed tubers of varieties Kennebec and Katahdin.

Publications: Differential Host and Serological Relationships of Potato Virus M, Potato Virus S and Carnation Latent Virus. Begnall, R.H., C. Wetter, and R. H. Larson. Phytopathology 49: 435-442. 1959.

The Inhibitory Activity of Plant Juices on the Infectivity of Potato Virus X. Blaszcak, W., A. Frank Ross, and R. H. Larson. Phytopathology 49:784-791. 1959.

Size and Shape of the Particles of Potato Virus S, Potato Virus M, and Carnation Latent Virus. Brandes, J., C. Wetter, R. H. Bagnall, and R. H. Larson. Phytopathology 49: 443-446. 1959.

A Yellow Strain of Potato Virus X. Hansen, A. J., and R. H. Larson. Am. Potato Jour. 36:9-104. 1959.

Potato Virus S Recovered from the Roots of the "Immune" Variety Saco. Larson, R. H., and N. Oshima. Am. Potato Jour. 36:229. 1959.

Some Common Stem Streaks of Potato. Robinson, D. B., G. D. Easton, and R. H. Larson. Am. Potato Jour. 37: 67-72. 1960.

Corky Ringspot of Potato A Soil-Borne Virus Disease. Walkinshaw, C. H., and R. H. Larson. Wisconsin Univ. Agr. Exp. Sta. Research Bull. 217:1-31. 1959.

Evaluating Potato Seedling Varieties for Field Immunity from Potato Virus A. R. E. Webb and E. S. Schultz. Amer. Potato Journal 36: 275-283. 1959.

Wilt Control Reduces Potato Losses. R. E. Webb and Reiner Bonde. Maine Farm Research. pp. 32-34. July 1959.

6. LATE BLIGHT EPIDEMICS

CR

Problem: Potato late blight fluctuates greatly in its destructiveness from year to year and from one location to another. Effective chemical control measures are available but are economically feasible only if they are applied at the proper time. They are too expensive to be applied routinely if the disease is light, but yield great returns when the disease becomes epidemic. Accurate experimental seasonal forecasts based upon the epidemiology (study of factors affecting initiation, spread, and severity) are needed to provide economical control for this disease.

Program: This continuing long-range program of applied and basic research is conducted at Ames, Iowa; Raleigh, North Carolina; and Newark, Delaware in cooperation with the thirty-eight State Experiment Stations in the Eastern half of the country. It involves about 2 professional Federal man-years annually.

Progress: In the north-central region, laboratory and field research on the factors involved in the development of potato late blight (*Phytophthora infestans*) was conducted. The laboratory work was planned primarily to obtain information on the effect of temperature on the initiation and duration of sporulation, germination, and infection, the critical stages in the life history of the fungus. No sporulation took place on lesions on detached leaves held at 45° F. At 50° The minimum time for sporulation was 8 hours; at 55° it was 6 hours.

Exposure to the temperature range 44° - 63° resulted in some sporulation after 12 hours. Low percentages of sporangia germinated after exposure to temperatures ranging from 70° to 83° through 24 hours. Some germination occurred after 6 hours exposure to temperatures fluctuating between 69° and 72°, and some after 6 hours at 71°. Comparison of results obtained from experimental prediction of blight-favorable weather on the temperature-90 percent relative humidity basis with results from methods depending on temperature and rainfall records showed that the former procedure is definitely better suited to the conditions of the north-central region.

A cooperative project with the U. S. Weather Bureau showed that an analysis of the five- and thirty-day weather forecasts permitted fairly accurate predictions of the occurrence and severity of late blight in the north-central region. Experimental predictions for all of the four commercial potato-growing areas in the southeastern region were very accurate. They were issued when the coincidence of a favorable temperature range

and of relative humidity of at least 90 percent, recorded by hygrothermographs in or near fields, together with the weather forecasts, indicated the existence of blight-favorable conditions for a sufficient period preceding and following the time of prediction.

Plans: Investigations will be continued to develop more accurate criteria for determining environmental conditions which are conducive to late blight epidemics. "Late blight gardens," potato plots planted with inoculated blighted tubers to insure infection, will be located in isolated and strategic geographical regions, and used throughout the season as a means for comparing the initiation, spread, and severity of late blight in these experimental gardens with the same in growers' fields.

Cooperative work with the Weather Bureau will be expanded in all regions where late blight epidemiological studies are being made in the hope of developing more extensive and longer range experimental disease forecasts.

Publications: Re-evaluation in Maine of Three Methods Proposed for Forecasting Late Blight of Potato. R. A. Hyre, Reine Bonde, and F. E. Manzu, Plant Disease Reporter 44: No. 4, April, 1960.

Weather Map Analysis - An Aid in Forecasting Potato Late Blight. Jack R. Wallin, and John A. Riley, Plant Disease Reporter 44: No. 4, April, 1960.

7. NEMATODE CONTROL

CR

There is no research involving potato nematodes to be reported for 1960, except that which is already included under breeding.

E. Insect Control

8. INSECTS AFFECTING POTATOES

ENT

Problem: Potato growers have to contend with many kinds of insects, several hundred species being known to feed on the potato in the United States. Work is needed to develop more effective and economical and less objectionable methods of control with particular reference to avoiding the accumulation of excessive insecticide residues in the soil and on the crop. Work is particularly needed on aphid vectors of leafroll disease, on the southern potato wireworm, the Colorado potato beetle, and the potato flea beetle because of apparent increased resistance of these insects to available insecticides.

Program: A continuing long-term program involving basic studies on the ecology, physiology and pathology of insects that attack potatoes in

the field or transmit virus diseases, as well as applied research on their control, conducted in Washington, Maine, Colorado and South Carolina, in cooperation with the respective experiment stations, the Washington State Department of Agriculture, the Washington State Potato Commission and industry, and involving about 5 professional Federal man-years annually.

Progress: Wireworms. Continued basic studies on the biology of the southern potato wireworm in South Carolina strongly indicated the normal food of the insect to be weed seeds and not potato tubers. This explains the tremendous population of adults caught in light traps, the poor correlation often obtained between wireworm populations and damage to potato and the large number of wireworms found near the soil surface in undisturbed weedy fields during the fall. It had been extremely difficult to rear the insect on potato but these findings have already led to the development of rearing methods that will facilitate the production of large numbers of wireworms for biological studies and for laboratory screening of new materials.

Considerable progress was made in the development of effective and safe methods of controlling the southern potato wireworm in areas in the Southeast where it has developed a high degree of resistance to previously toxic insecticides. The relatively new commercial use of parathion usually gave adequate control when applied to the late summer-fall cover crop or when applied directly to the soil before potatoes were planted. Usually a $\frac{1}{2}$ pound per acre foliage application of parathion during late August and repeated in September, or a single 2-pound application to the undisturbed soil surface in either granular or spray form during the fall or winter, were effective. However, soil applications of parathion after deep plowing often have not been effective.

As a result of previous research a preplanting soil application of Diazinon at 1 to 2 pounds per acre was recommended to growers for the 1959-60 season. This treatment continued to give excellent control and appeared to be more effective than parathion against such wireworms as had been buried deeply in the soil by plowing.

Aphids and other foliage insects. In Northeastern Maine, field studies indicated that the green peach aphid and buckthorn aphid are the most susceptible to insecticides early in the spring when they first migrate from other host plants. Apparently they become more tolerant to insecticides as they become better adjusted physiologically to potatoes. This tends to substantiate similar findings in Washington and would indicate that greater emphasis should be given to early applications of insecticides during the time of the spring migrations of the insects. Damage by aphids in the summer is greatly influenced by the thoroughness of aphid control in the early spring. Progress was made toward the development of insecticide application schedules sufficiently effective against aphids to control aphid-spread leafroll

disease. Most promising results were obtained with the systemic insecticide Di-Syston applied at 1 pound per acre in the seed furrow at planting time. Demeton was also promising when applied in this manner and endrin when applied in 4 well-timed foliar applications. The systemic treatments are still experimental. Commercial use in growing table stock potatoes will probably depend upon establishment of small tolerances.

In Washington basic studies on the cause of apparent resistance of the green peach aphid to phosphorus insecticides in the Northwest indicated that a number of factors may be involved. It seems probable that the reported resistance of the green peach aphid to phosphorus-type insecticides in Washington may be only partly due to insecticide resistance, partly to environmental conditioning which can result in added vigor, and partly to physiological changes in the aphid's food during the normal growth and senescence of the host plants.

In Washington one pound of Trithion in 5 to 8 gallons of water per acre controlled spider mites for 10 days to 2 weeks. However, resistance to this insecticide may be developing, since unsatisfactory control has been obtained in some areas following the third consecutive year's use of Trithion. In three locations, Phosdrin, applied at $\frac{1}{2}$ -pound per acre, gave immediate control of the adults and nymphs but a second application in 5 to 8 days was required to kill those that survived in the egg stage.

Thiodan, used at 1 pound in 5 to 8 gallons per acre with aircraft in Washington, continued to give excellent control of the green peach aphid and also satisfactory control of the Colorado potato beetle. The recently discovered fumigation action of Thiodan was further demonstrated by the recovery of Thiodan in air samples collected in a treated potato field 3 days after application.

Granular phorate, applied beneath potato seed pieces at planting time in Washington, gave satisfactory control of aphids, Colorado potato beetle, iris whitefly and two-spotted spider mite for the first 75-80 days of plant growth. Considerable phytotoxicity appeared when the 3-pound rate was used in sandy soil. Plants grew slowly at first in both sandy and loam soils when 1-1/2 to 2 pounds were used but caught up with non-treated plants by mid-season.

Studies of the six-spotted leafhopper as a vector of the aster-yellows disease of vegetables, known as purple top in potato, indicated that summer infestations in the Western Great Plains States result from a spring migration from southern areas in which the insects overwinter. This migration apparently originates largely in the overwintering area in Missouri and Arkansas and its intensity is governed by overwintering conditions in this area and wind currents during the migration period in April and May. Another overwintering area in Texas from which

six-spotted leafhoppers move progressively northward as the season advances may be an important source of summer infestation to New Mexico and Southern Colorado, particularly in years of large leafhopper population.

Laboratory and field studies in Colorado have shown that the six-spotted leafhopper breeds and increases chiefly on cereal crops and grasses, and does not breed readily on the potato and some other plants. However, in nature it visits the potato frequently and can transmit the purple-top virus to it. When the cereal crops and grasses reach the heading stage they are no longer suitable for leafhopper feeding and breeding, and the insects present on such crops then move to other plants, including the potato.

Plans: The work under way will be continued at about current levels with special emphasis on basic studies on the problems of increased resistance to insecticides and on the development of other means of control, especially by cultural methods and by the utilization of diseases and other biological enemies of the insect pests.

Publications: Response of Different Strains of the Green Peach Aphid to Malathion. F. H. Shirck. Jour. Econ. Ent. 53(1):84-88, Feb. 1960.

Millipede Injury to Potatoes. B. J. Landis and C. W. Getzendaner. Journ. Econ. Ent. 52(5):1021-2, Oct. 1959.

The Economic Importance of Pleurophorus caesus Creutz. B. J. Landis. Jour. Econ. Ent. 52(6):1215, December 1959.

Potato Insect Control Calendar for Eastern Washington. B. J. Landis. An unnumbered mimeograph prepared and released by the Adams Co., Wash. Ext. Serv., February 1960.

The Aphid Problems on Potatoes. B. J. Landis. Wash. State Univ. Proc. 1960 Potato Growers Conferences: 13-15, February 1960.

Control of the Southern Potato Wireworm in Coastal South Carolina in 1960. W. J. Reid, Jr., F. P. Cuthbert, Jr., and Augustine Day. S. C. Agri. Exp. Sta. Z and E Mimeo Series No. 53:1-3, December 1959.

New Hosts of the Foxglove Aphid. W. A. Shands and H. E. Wave. Proceedings of the Ent. Soc. of Wash. 62(8):86, June 1960.

Host Plants of the Six-Spotted Leafhopper and the Aster Yellows Virus and Other Vectors of the Virus. R. L. Wallis, USDA-ARS 33-55:1-15, 1960.

F. Mechanization of Production and Harvesting

9. PRODUCTION AND HARVESTING EQUIPMENT

AE

Problem: Develop methods and equipment for improving production, harvesting, and on-the-farm handling of potatoes in order to lower cost of production while maintaining quality.

Program: An applied research program involving the use of engineering principles in solving harvesting and farm handling problems is being conducted on a continuing basis at East Grand Forks, Minnesota in cooperation with the Red River Valley Potato Growers Association, the Agricultural Experiment Stations of North Dakota and Minnesota, potato processors, farmers and manufacturers of field machinery for potatoes. Two Federal professional man-years annually are involved in this research.

Progress: The method of seedbed preparation may affect clod formation, soil compaction, and yield. The tests this fiscal year showed that "no preparation ahead of planting" resulted in as high yields and about the same amount of clods as "conventional seedbed preparation," the same findings as in FY 1959.

It is estimated that 30 cwt. of potatoes per acre are often lost due to spillout on the side of digger blades. Controlling the depth of the digger blades is important. Two designs of depth indicators were developed and proved useful. Two manufacturers plan to provide depth indicators for some of their 1960 models.

The results of a differential cost analysis between field and at-the-storage filling of pallet boxes with potatoes were published. The study showed that overall costs of harvesting, box filling, transporting, and placing into storage cannot be reduced by substituting field filling for filling boxes at the storage site.

A previous study showed the need for an effective machine for cutting seed into six pieces. A unit was designed and constructed for cutting 7-ounce to 13-ounce tubers into 6 pieces of approximately uniform size and shape. Test of this machine showed that one operator could produce 17,000 seed pieces per hour, an amount equal to 4 or 5 workers cutting potatoes by hand. The results will be published early next year.

Plans: The seedbed preparation work will be repeated for one more year and if results are the same it may be possible to recommend minimum tillage practices for potatoes. During the 1960 season final data will be obtained so that a report can be made available on type of blade and blade substitutes best suited for various soil conditions. The work on filling pallet boxes was terminated June 1960. No further research is planned on the potato cutting unit.

Publications: Field Filling of Pallet Boxes Not Recommended for Irish Potatoes. G. W. French. USDA-ARS 42-36, October 1959.

Increasing Potato-Harvester Efficiency. A. H. Graves and G. W. French. USDA Handbook No. 171, December 1959.

10. PESTICIDE APPLICATION EQUIPMENT

AE, ENT

Problem: There is need for work on the reduction of cost and the improvement of effectiveness of pest control by the development of improved methods and equipment for applying pesticides by aircraft, surface, and soil machines.

Program: A continuing long-term program involving laboratory and field studies of pesticide application equipment for control of plant diseases, insects, and soil inhabiting pests involving work on aircraft, ground, and soil equipment, on spray droplet sizes, and on the behavior of aerosols, dusts and granules, with headquarters at Forest Grove, Oregon; Columbia, Missouri; Wooster, Ohio; Beltsville, Maryland; and Ames, Iowa, in cooperation with the Washington State Potato Commission and State Agricultural Experiment Stations of Washington, Oregon, Missouri, Minnesota, Ohio and Iowa, involving about four professional Federal man-years annually.

Progress: Aircraft Equipment for Application of Pesticides. Joint studies by agricultural engineers and entomologists were conducted on pesticide dispensing equipment. The work included tests of effectiveness in control of green peach aphid on potatoes. Endrin at 0.45 lbs. per acre was used in spray formulations. Sprays applied at 10.7 gallons per acre were more effective in aphid control than at 5.7 gallons per acre rate, with 84.8 percent control and 72.5 percent control respectively. Significantly better aphid control was obtained in a clean cultivated crop of potatoes than in a weedy crop. No correlation was found between wind velocity and control obtained when wind velocities varied from 0.7 mph to 9.2 mph and tests extending from morning to evening. These results coincide with those of 1958 tests, when no difference in aphid control was shown with wind velocities varying between 0-3 mph to 6-8 mph. The use of extended flaps during a spray application did not improve the insect control with endrin sprays.

A series of tests was conducted to determine spray penetration and deposit resulting from aerial application to certain crops. The dye recovery method was used to determine rates of deposit on the sampling areas. Pressure adhesive labels $\frac{1}{2}$ " x 1" were attached to the leaf surfaces and used as sampling areas. Labels were placed on both the top and under surfaces of leaves at various foliage levels. Tests on potatoes indicated that spray was deposited at the upper and lower plant levels and on both leaf surfaces in varying degrees depending upon position on the plants.

The highest deposits were at the top of the plants with reduction in deposit and coverage toward the ground. Similar results in general were found in tests on pole beans and corn. Further developments in techniques for this type of testing and evaluating spray equipment is needed.

Some individual tests on the N3N biplane with and without the use of a spoiler mounted under the center of the fuselage in various positions indicated that the normal crossover of spray from right of center to left of center could be controlled by properly positioning a spoiler. Replicated tests using the same spoiler position and nozzle arrangement, however, showed that variations in swath patterns were as great as the differences found in patterns with and without the use of a spoiler.

Spray Equipment for Control of Insects and Diseases by Ground Machines. Work continued on the development of equipment and techniques for the application of insecticides and fungicides to crops by ground machines. No significant difference was shown between application rates of 20 and 40 gallons per acre in control of anthracnose and foliage diseases of canning tomatoes. Sprays applied down the row or with the air and spray pattern directed parallel to the rows was more effective than the customary method of spraying across the rows at right angles. The development of equipment for harvesting canning tomatoes no doubt will result in closer planting and must receive consideration for equipment and methods of spraying. One exploratory test was run with the customary 2500 plants per acre compared to 5000 plants per acre. Control of disease was not significantly different for either plant population. A special spray formulation of colloidal copper was compared with Maneb for disease control on tomatoes using the air-blast sprayer. The colloidal copper was not effective in control of anthracnose while the Maneb gave satisfactory disease control. Hydraulic spray applications at 20 and 40 gallons per acre were as effective as 160 gallons per acre. In all comparisons the same amount of fungicide was used per acre.

Studies were continued with the trailing boom type sprayer developed in cooperation with the Agricultural Experiment Stations of Oregon, Washington and Idaho and Entomology Research Division, ARS. Emphasis is being placed on penetration and uniformity of leaf coverage. Combinations of nozzle positions and patterns are a major consideration. Pressure adhesive labels and dye recovery method is used to measure rates of spray deposit. Results to date have shown somewhat irregular deposits on the foliage.

Spray Atomization and Relation to Pest Control. Field experiments were conducted to determine the effect of drop size of a spray on the pesticidal results. Fungicidal sprays of controlled mass median diameter were applied to randomized, replicated tomato plots. The fungicide, Manzate, was applied at half the recommended rate to intensify differences in disease infection. Effectiveness of spray treatments was measured by

net yield, anthracnose and early blight infection on fruits and percent defoliation. Two series of flat spray patterns ranging from about 100 microns to 500 microns mass median diameter were applied. One series was applied at 40 gallons per acre and the other at 15 gallons per acre. Mass median diameters were varied by 100 micron increments by changing spray pressure. A similar series of hollow cone sprays ranging in mass median diameter from about 100 microns to 400 microns was applied at 40 gallons per acre. Differences in disease infection and yield were not significant and show little relation to drop size for any of the spray patterns or application rates used in the experiments. The lowest percent defoliation occurred in the plots sprayed by a hollow cone pattern of small mass median diameter. Variation in operating pressure apparently affects the drive of the spray material as well as drop size, and the technique for measuring this factor might contribute to the evaluation of the results of such experiments as these.

Equipment for Application of Chemicals to Soil for Control of Soil Pests. The object of this program is to develop equipment and techniques for the chemical treatment of soil for the control of pests in orchards, forest nurseries, ornamental plantings, vegetables, and other crops. The field experiments were done in cooperation with the Department of Botany and Plant Pathology and Department of Entomology, Ohio Agricultural Experiment Station. Liquid and granular forms of nematocides, herbicides, insecticides, and fungicides were applied to soil in which various crops including vegetables, ornamentals, locust tree seedlings, tobacco, and grape cuttings were grown. Thirty-six different formulations alone or in combinations with each other were used during the season. Nylon, teflon, stainless steel, neoprene, polyethylene, and bronze materials have given good service in the application equipment used in making these treatments. The field cultivator with spring-type shanks proved to be readily adaptable to row treatments and easily set up on a tool bar for different full width treatments. The full width and row-type rotary tiller also met field requirements very well. A device for laying plastic film to retain a highly volatile fumigant as it is applied was prepared for use with these applicators and used at several locations during the season.

Small Particle Behavior. A study was continued to provide basic theoretical concepts and experimental data needed for development of pesticide application equipment and techniques which have optimum depositing efficiency and distribution characteristics. Because of the effect of particles upon each other, it has been found that behavior of groups of particles cannot easily be predicted from the behavior of single particles. A study has been initiated which attempts to describe particle behavior from a statistical point of view.

A scanning type of instrument is under development for measuring the distribution of chemicals on plants. An intense beam of ultraviolet radiation is directed upon a rotating cylinder or disk upon which the

treated sample is to be mounted. The visible fluorescent light emitted is sensed by a microscope-microphotometer system, and the signal is fed into an appropriate recorder. An instrument enclosure and ultra violet illumination system have been designed and constructed.

Plans: Improved granular dispensing equipment for aircraft will be developed and tested. Lower rates of application and evaluation of swath distribution and foliage coverage with air blast sprayers will be investigated. Tests will be conducted in an effort to improve uniformity and coverage of the row crop sprayer duster. Study of small particle behavior will be extended.

Publications: USDA Aims New Tools at Pest Target. V.D. Young. Western Farm Equipment, April, 1959.

Characteristics of an Aircraft Distributor for Granular Materials. W. G. Lovely and F. M. Cunningham. USDA-ARS-42-25 publication, May, 1959.

Spray Deposits Measured Rapidly - L. A. Liljedahl and John Strait. Agricultural Engineering, Vol. 40, No. 6, pp. 332-335, June, 1959.

Disease Control Using Air-Blast Sprayers. J. D. Wilson and Frank Irons. American Vegetable Grower: 9, 40 & 41. June, 1959.

Electrostatic Precipitation of Pesticidal Dusts, An Outline of Research and Literature. R. D. Brazee and W. F. Buchele. USDA-ARS-42-49 publication. July, 1959.

Versatile Sprayer-Duster. V. D. Young and J. C. Chamberlin. American Vegetable Grower: 24. November, 1959.

The Swath Pattern of Tomato Disease Control with an Air-Blast Sprayer. J. D. Wilson and Frank Irons. Ohio Agricultural Experiment Station Research Circular 77. November, 1959.

Hand Sprayers and Dusters. Frank Irons. USDA Home and Garden Bulletin No. 63. December, 1959.

"Plant-safe" Material Seems to Combat Root-Knot. J. D. Wilson and Orve K. Hedden. Ohio Farm and Home Research of Ohio Agricultural Experiment Station. Vol. 45, No. 1, January-February 1960.

II. UTILIZATION RESEARCH

A. Chemical Composition and Physical Properties

1. CHEMICAL CONSTITUENTS

EU

Problem: The lack of knowledge concerning constituents of the potato, and of changes brought about in these constituents during processing, is limiting the development of new and improved potato products. Our knowledge of potato composition must be increased by studies on the isolation, identification, and quantitative determination of these constituents.

Program: A continuing program of basic research at EU, involving nearly six professional Federal man years annually. Cooperative studies are underway between EU and the Maine Agricultural Experiment Station.

Progress: Organic and Free Amino Acids. With the availability of methods developed at EU for extraction and determination of potato acids, research has proceeded in the study of how the quantities of acids may be related to the specific gravity (or total solids) value and how they may change during potato storage. For lack of qualitative and quantitative methods in the past, little has been known concerning the possible effects of cultural and storage conditions on the acid picture of potatoes.

1959 Crop Kathahdin potatoes, grown at Presque Isle by the Maine Agricultural Experiment Station and placed in 37° F. storage there, were sampled (100-150 pounds) monthly and the samples shipped to EU for analysis. Each lot received was separated by brine solutions into sub-lots of high, intermediate, and low specific gravities. Total solids, total nitrogen, and the soluble nitrogen fraction were determined each month on samples from each of the three specific gravities. Extracts of the potato samples were run through an automatic amino acid analyzer to determine the quantities of 21 known amino acids and 7 unknown amino compounds present. This survey constitutes the most thorough analysis of potato nitrogen constituents ever undertaken.

In addition to the amino acids, the quantities of the relatively strong acids such as citric and malic are also being determined in the potato extracts. Tabulation of data and analysis of the findings are now in progress, and conclusions must therefore be deferred.

An official of a company now building a \$1-3/4 million potato starch plant in Maine recently informed us of their continuing interest in recovering the amino acids from the processing water. This company has been supplied with full information concerning methods developed at EU for isolation and recovery of the principal amino compounds.

Total Nitrogen and Fractions. In the analysis of Maine Katahdin potatoes, referred to above, the quantity of total nitrogen substance calculated on the fresh weight of potatoes was nearly the same for all samples regardless of their total solids content. On the dry basis, then, higher solids potatoes contained a lesser amount of nitrogen substance than did lower solids potatoes. This is believed to be a new observation and, if subsequent results show it to be generally applicable, will be of fundamental interest to nutritionists and food processors. As in the relationship borne by the total nitrogen, the amounts of soluble nitrogen and insoluble nitrogen fractions also were found to be greater (on the dry basis) in lower solids potatoes than in higher solids tubers. Approximately 60% of the total nitrogen of the potatoes used was classified as being in the soluble fraction, that is, extractable by 70% alcohol.

Plans: The analytical survey of Maine potatoes will be continued. Particular attention will be given to variation in the amounts of nitrogen constituents as a function of total solids and to changes in the acids picture during potato storage. Emphasis will be placed on improving the sampling methods since the monthly shipments from the stored 1959 crop lot showed lack of homogeneity with respect to specific gravity distribution.

Insofar as time will permit, it is planned to give attention to changes that occur in the amino acids picture of potatoes as the result of various types of processing.

Publications: Functions of the protein and other nitrogenous fractions of potatoes in chip color development. Ora Smith and R. H. Treadway. American Potato Journal 37: 139-43. 1960.

A preparative column for the ion exchange isolation of amino compounds. E. A. Talley and W. L. Porter. Journal of Chromatography 3: 5, 434. 1960.

Apparatus for collecting and drying organic acid fractions. J. J. Schwartz. Journal of Chromatography 3: 491-3. 1960.

2. CHEMICAL COMPOSITION AND PHYSICAL PROPERTIES RELATED TO TEXTURE

WU

Problem: Improvement in potato utilization, through the development of new processes and products, is limited by a lack of knowledge of carbohydrates and related constituents of the potato and of chemical and physical changes that can be brought about in these constituents during processing.

Program: A continuing program of basic research is being conducted involving 2 professional Federal man-years per year. Cooperative studies conducted at the Idaho Agricultural Experiment Station have been concluded.

Progress: Precooking Heating of Potatoes: Empirical studies reported by others have indicated that a moderate heat treatment in water prior to cooking makes potatoes more firm and less subject to stickiness when mashed. Earlier it was reported that the increased firmness was caused by a reduced solubility of the starch constituents and also that starch gels made from suspensions of isolated starch were made more firm (less soluble) by a similar preheating prior to gelatinization. Recent studies demonstrated that gel strength of starches isolated from different lots of potatoes vary considerably. Gels made of starch isolated from a lot of Idaho-grown Russet Burbanks were firmer than gels made from lots of Washington-grown Russet Burbanks and California-grown White Rose, Red Pontiac, and Kennebec potatoes.

Further studies on the preheating treatment demonstrated similar effects on the in situ starch of cooked potatoes and on the gelatinized starch in a gel made from a suspension of isolated starch. Thus, it was feasible to conduct preliminary laboratory tests on a very small scale with isolated starch to gain some insight into the influence of various processes on product quality without the expensive and time-consuming procedures of treating rather large quantities of potatoes in pilot plant processes.

Gel strength of isolated potato starch was tested in solutions of chemicals rather than by the usual procedure in distilled water. An ethylene-diamine tetracetic acid solution gave a firm gel; a calcium chloride solution, a weak gel. This indicated that dissolved components in potato sap may influence the gel strength of starch in cooked potatoes and, consequently, the textural qualities of potato products. Comparative studies with wheat starch demonstrated much the same effects. Because wheat starch contains little or no phosphorous, the results indicated that the gel firming phenomena were not related to an interaction between phosphorous and calcium.

Role of Carbohydrates in the Textural Quality of Potato Products

In the extensive contract study of chemical composition and organoleptic evaluation of potatoes, significant correlations were found between texture of cooked potatoes and the following physical and chemical factors: specific gravity, total solids, alcohol-insoluble solids, starch, total ash, alcohol-insoluble ash, and alkalinity of ash. On the other hand, no significant correlations were found between texture and pectin; crude fiber; total calcium, magnesium, and phytate phosphorous. These findings indicate that starch must be the principal factor in determining textural character of cooked potatoes and that the cell wall and intercellular substances are of much less importance.

That these substances have some influence on texture was demonstrated by their chemical modification in situ, by treatment with calcium chloride, for example. This had a marked effect on the firmness of dehydrated potato dice and the freedom from blistering of potato chips.

The University of Idaho workers also developed and evaluated an improved procedure devised at WU for measuring the degree to which potatoes slough while being cooked in water. This textural characteristic is important to the canning industry, where sloughing is an indication of poor quality, and the freezing and dehydration industries, where sloughing is an indication of mealiness that is desirable if potatoes are to be mashed and dried or made into frozen French fried potatoes. The procedure will be of value for controlling the quality of raw material for potato processing. In tests of 59 experimental lots, the sloughing test correlated well with specific gravity of tubers and organoleptic evaluations of mealiness. Kennebec and Russet Burbank potatoes were generally more mealy than the Early Gem variety. No consistent trend in mealiness was observed in connection with the date of harvest throughout a normal harvest season.

Plans: Work will be continued at a slightly lower level. Further emphasis will be given to fundamental studies of chemical and physical changes in potato starch in relation to processing treatments.

Publications: Changes in the Physical Conditions of Starch of the Potato During Precooking Heating. A. L. Potter, E. M. Neel, R. M. Reeve, and C. E. Hendel. Am. Potato Jour. 36 (12), 444-449 (1959).

Microscopic Structure of Potato Chips. R. M. Reeve and E. M. Neel. Am. Potato Jour. 37 (2), 45-52 (1960).

3. ANTIOXIDANTS TO CONTROL OXIDATIVE DETERIORATION OF DEHYDRATED POTATOES

Problem: Oxidative deterioration of dehydrated potato products limits shelf life and makes necessary expensive packaging. Such deterioration is only partially controlled by antioxidants now available.

Program: A five-year fundamental investigation on the isolation and characterization of naturally occurring polyphenolic antioxidants, and their chemical modification to strengthen their antioxidant activity for use in enhancing stability of food products, is being conducted under P.L. 480 at the Research Establishment and Experimental Factory of the British Ministry of Agriculture at Aberdeen, Scotland.

Progress: Embelin, an antioxidant isolated from the plant, Embelia ribes, was found to be three times as active as propyl gallate (an

accepted antioxidant) when tested with linoleic acid. The antioxidant activities of three synthesized derivatives of leucomelone were also found to be about three times that of propyl gallate.

Plans: Fundamental studies of the antioxidant mechanism of isolated plant polyphenolic compounds will continue.

4. CONTROL OF NON-ENZYMATIC BROWNING IN DEHYDRATED POTATOES WU

Problem: The chemical mechanism by which sulfur dioxide reacts to protect dehydrated potatoes from non-enzymatic browning is not well understood.

Program: A five-year fundamental investigation of the chemical fate of sulfur dioxide in dehydrated vegetables, in connection with its role in the prevention of non-enzymatic discoloration, as a foundation for improvement of quality stability is being conducted under P. L. 480 at the Covent Garden Laboratory of the British Ministry of Agriculture, London, England.

Progress: Radioactive sulfur (S^{35}) was added by sulfiting cut-up potatoes. A slight loss of sulfur occurred during dehydration and part of the S^{35} was located in compounds other than sulfite in the dried tissue. Chemical reactions concerned with non-enzymatic deterioration of dehydrated vegetables were studied by use of simplified, model browning solutions. Browning effect was increased in the presence of phosphate ions. The browning tendency of reaction products of amine bisulfites and glucose was determined. Substances extracted from potatoes during water blanching were examined for browning inhibition properties.

Plans: Fundamental studies on the nature of browning and its control by sulfur dioxide in dehydrated potatoes will continue.

B. New and Improved Food Products and Processing Technology

5. IMPROVED PRODUCTS, PROCESSES, AND EQUIPMENT EU, WU

Problem: Potato utilization is limited by existing products and processes. New products, new processes, and lower costs are required to develop new markets and enlarge existing markets for potato products.

Program: A continuing technological study in cooperation with potato processors in the principal potato-producing States is being conducted at WU with four professional Federal man-years per year. A cooperative program with the California Long White Advisory Board with one professional, industry-sponsored man-year per year was terminated recently because the Marketing Order on California Long White potatoes was dissolved by grower vote.

Research involving basic investigations, technological, and engineering studies of continuing duration at EU involves the services of between 3 and 4 professional Federal man years annually in laboratory research

and nearly 4 man years in pilot plant studies.

Progress: Process for Instant Potato Granules: Investigations have continued at WU to develop a method avoiding the recycling of dry product that is currently involved in the conventional process for manufacture of potato granules. Variables in unit operations of granule manufacture were studied further and products of controlled bulk density (either high or low, as desired), good texture when reconstituted with boiling water, and a high level moisture absorption were developed. Important factors related to product quality included temperature of cooking; severity of mashing and mixing actions; temperature and duration of conditioning mashed potatoes; and design of mixing, conveying, and drying equipment.

Two processes were developed on a laboratory scale. Both processes involve a new low-temperature (185 to 190° F.) cooking of sliced potatoes. By so cooking potatoes the texture of the reconstituted product can be controlled. One process involves a partial drying of mashed potatoes on a single-drum dryer, conditioning the product by holding at a low temperature and granulating it in a "trough granulator-dryer". In this device the conditioned potato mash of about 55% moisture is subjected to mild compression and shearing action while it is slowly dried to 35% moisture, and reduced to a friable product of fine particles. This equipment and procedure overcame the difficulty in producing satisfactory granules where the first stage was by drum drying. The high temperature of the drum dryer causes the partially dried product to have a strongly cohesive nature that tends to result in (1) a large particle size of granules and lumps in the ultimate mashed potatoes or (2) a resistance to granulation and release of free starch and stickiness in the mashed potatoes.

The second process was designated as a high moisture absorption process in that a given weight of potato granules will absorb 10 to 15% more moisture than conventional potato granules, while yielding mashed potatoes of identical texture. By this process mashed potatoes are conditioned at a cool or freezing temperature preliminary to drying, and then reduced to a friable moist powder by a two-step drying procedure. The first step requires novel drying equipment with rotating blades that apply mild compression and shear actions; and the second step, through the critical 55 to 35% moisture range is in the "trough granulator-dryer". For the high moisture absorption process, mashed potatoes are conditioned at the normal moisture content for a long enough period to cause changes that are believed to be connected with cross linkages that occur within starch molecules and that preserve porosity in the product throughout subsequent operations. Such a porosity may account for the increase in moisture absorption that has been observed for such products.

Preserved Products from California Long White Potatoes. In the course of industry-sponsored research at WU on the processing quality of California Long White (White Rose) potatoes, high quality potato

granules, potato chips, and frozen French-fried potatoes were produced immediately after harvest. However, large amounts of reducing sugars developed in the potatoes after very short storage, which caused the fried products to turn dark during cooking. The relationships of cultural and holding conditions on processing quality were subjected to preliminary observations but the project was terminated prior to the development of positive results.

Potato Flakes. A number of significant advances in potato flakes technology were made at EU during the year. For one, through the use of precooking, cooling and addition of emulsifiers it is possible to make potato flakes which contain practically no free soluble starch; consequently, rehydration provides a very mealy mashed potato. This high textural quality of potato flakes permits substantial increases in density by grinding to a small size. Grinding alone increases the bulk density to about 30 pounds per cubic foot. An additional modification of the process, granulation, further increases bulk density to about 56 pounds per cubic foot, equivalent to that of commercial granules. These higher densities are important for military and institutional uses and the development of higher densities in both potato flakes and in granulated potato flakes will provide manufacturers with greater economies and greater flexibility to meet the demands of various types of markets.

A second major advance has been the discovery that about 70% of the antioxidant combination BHA plus BHT, steam distills away from mashed potatoes during manufacture of potato flakes. This finding will improve the position of potato flake producers in their petition to the Food and Drug Administration to permit the use of BHA and BHT in necessary amounts. Concurrently, experiments are going forward on other antioxidants which may prove to be satisfactory substitutes.

In a third advance it has been found that it is possible to fortify potato flakes with several vitamins. Inasmuch as recent surveys have shown that Vitamins A and C are still at unsatisfactory levels in the diet of significant segments of the national population, it is noteworthy that Vitamins A and C can be added in amounts such that after storage for seven months the Vitamin A and C content is present at a level to provide 50% of the adult daily requirements in 1 serving. Moreover, the cost amounts to only a few hundredths of a cent per serving.

Industrial Status. During the 1959-60 processing season, ten potato flake plants in seven states were operating. Individual plant capacities ranged from 3 to 16 million pounds per year. Estimated total capacity of the plants as operated during the 1959-60 season is 50 million pounds. In the coming processing season, beginning in late September or early October, new plants (Fosston, Minn., Blackfoot, Ida., Idaho Falls, Idaho) and expansion of already existing facilities (Grafton, N.D., Grand

Forks, N.D.) are expected to boost capacity to about 62 million pounds. A drier of larger size has been introduced in the industry by two equipment manufacturers. This unit is 5' in diameter by 15' long, and can produce about 3 million pounds per year.

The precooking and cooling steps developed at EU for the potato flake process are now in commercial use in granule and frozen French fried potato manufacture.

Potato Pieces - Dice, Slices, etc. The early work on potato flakes at EU which showed that the texture and rehydration characteristics can be varied and controlled by certain pre-drying techniques has been extended to other processed products. These include French fried potatoes and potato dice, with emphasis on the latter. The pre-drying steps provided potato dice which rehydrated faster and to a greater degree than conventional dice; however, the experimental dice were tougher and harder to cook. The disadvantages were subsequently eliminated by greatments during drying which change the physical structure of the potato piece. These treatments provide faster rehydration of the dehydrated dice and also provide more efficient drying in the latter stages of the drying period where moisture removal is difficult by existing commercial methods.

This "instantizing" of potato dice is accomplished by partially dehydrating them by conventional means, heating the partially dehydrated dice in a closed vessel with a quick opening lid until the water contained within the piece is superheated with respect to steam at atmospheric pressure, and then instantly discharging to atmospheric pressure. (A cereal "puffing gun" has been used for these experiments.) The pressure cooking effect (pressures of 20-60 p.s.i.g. within the chamber are developed), and the flashing of water vapor from all parts of the piece, provide a porous structure which permits much more rapid final dehydration and much more rapid rehydration of the dried product than are found in existing processes and products. The process has been applied successfully not only to potato dice ($3/8$ " cubes) but to carrot dice as well. Products rehydrate in boiling water in 5 minutes.

Chips. Last year's report mentioned a limited amount of research at EU on estimation of the reducing sugar content of potatoes by use of tablets employed in clinical testing. Based on laboratory tests, it was felt that the method was not sufficiently sensitive. However, it was suggested that potato processors try the method to evaluate it on a commercial scale. A report was recently received from the industry that this method may be useful for chippers to predict the frying color of potatoes.

Chippers commonly gauge the fat uptake of their product merely by comparing the amount of fat entering processing in a definite period and the total weight of chip output during the same interval. Fat

uptake of potato slices on frying may vary considerably, though, being inversely proportional to the solids content of the potatoes and dependent on certain other factors. Larger plants, those having laboratories, run only occasional determinations of fat content of chips because of lack of methods that are satisfactory from all considerations. A survey has been made of the various methods used in determining crude fat in potato chips and similar materials. Promising results have been obtained in the extraction of the fat without employment of the time-consuming reflux distillation of the Soxhlet method, but development of the proposed simplified procedure is not yet completed.

Prepeeled Potatoes. Results have been previously reported by EU on the effects of concentration of dipping solution, time of immersion, and addition of citric acid to the sodium bisulfite solution used in dipping peeled potatoes. Work on prepeeled potatoes at EU has been extended in order to determine the effects of the following variables on sulfur dioxide (SO_2) uptake and retention; temperature of the dipping solution; refrigerated storage time of the sulfited potatoes; and method of cooking the potatoes. When whole peeled potatoes were dipped in 0.5% sodium bisulfite -- 0.5% citric acid for 2 minutes, drained one minute and then assayed, the SO_2 uptake was of the order of 200 parts per million. French fry slices had a much higher SO_2 uptake under the same dipping conditions. Boiling the whole potatoes for 25 minutes reduced the SO_2 content to about 75 p.p.m. French frying the slices reduced their SO_2 value from about 600 to about 150 p.p.m. During 37° F. storage, raw French-fry slices lost SO_2 fairly rapidly for the first few days and then at a slower, nearly constant rate such that an appreciable quantity of SO_2 remained even after 2 weeks.

SO_2 in Potato Flakes. Flakes processors have indicated a need for a rapid method of determining the SO_2 content of their final product. By proper modification of the simple method developed at EU for assaying SO_2 in fresh potatoes, a scheme was devised for use with potato flakes. Copies of this method have been sent to all flakes manufacturers and to others expressing an interest.

Potato Flakes Texture. Some experiments have been made at EU in the attempt to elucidate how a monoglyceride, such as glycerol mono-palmitate (G.M.P.), acts on mashed potatoes to improve the texture of reconstituted flakes. The action of G.M.P. on potato starch is complex and is far from being understood at present. It has been established that the G.M.P. decreases the solubility of potato starch, increases the gelatinization temperature of the starch, and produces an anomalous viscosity-temperature curve during pasting of the starch.

After-cooking Discoloration. An investigation has been in progress at EU on a limited scale for several years on the type of discoloration that causes some lots of potatoes to darken after cooking, particularly at the stem end. Emphasis has been placed on analysis of the juice extracted from the stem-end and bud-end tissue in the search for chemical differences that might aid agronomists and horticulturists. As previously reported, the possible roles of polyphenols, nitrogen components, iron and potassium concentrations, of polyphenoloxidase potency, and of pH have been given prime consideration.

During the past year, a study was made of the uptake of iodine by potato juice. The fraction of the iodine that reacts quickly is taken as a measure of the reducing power of the juice. Additional iodine, taken up on long standing, is believed to be a measure of the unsaturated substance present. The unsaturation found in the stem-end juice was less than that in the bud-end juice. It is not understood at present how this observation may possibly be related to after-cooking discoloration.

A number of lots of 1959 crop potatoes grown in the Upper Michigan Peninsula were sent in for examination because of occurrence of discoloration. While blackening was not as severe as desired for research purposes, the cooked stem-end tissue from 10 out of 11 samples of this group was darker than the bud-end tissue. Of the various chemical factors suspected of involvement in after-cooking discoloration, only potassium showed some relation to blackening. The sample that blackened most had the lowest potassium content of all; there was always less potassium in the stem end than in the bud end.

Fourteen lots of 1959 crop Michigan and Wisconsin potatoes were received in early April 1960 following 40°-50° F. storage through the winter. After-cooking discoloration ranged from very severe through gradations to no discoloration. In these samples, blackening developed fully about 30 minutes after the potatoes had been removed from the steam cooker and allowed to cool in the open air. Light apparently had no effect on the blackening development. Potatoes cooled in a nitrogen atmosphere remained white until moved to the open air. In confirmation of observations made by others, blackening of these potatoes could be prevented by dipping them in a dilute solution of a phosphate chelating agent or citric acid before cooking.

While the chemical examination of the stabilized extracts from these blackening potatoes has not yet been completed, one fact stands out in support of previous results: the potassium content tends to be higher in the lighter tissue.

Plans: On potato flakes, research will be continued at EU to increase product density; to evaluate antioxidants other than BHA + BHT and to find optimum moisture contents of the product for longer shelf life; to incorporate milk solids in amounts large enough to permit rehydration with water alone; and to reduce processing costs.

Research on "instantizing" will involve testing of variables relating to process control and obtaining engineering data for cost calculation to the end that the process may be adopted commercially. Process will be applied to major potato varieties from important growing areas to determine their suitability or to modify the process to include them. Attention will be given to "instantizing" pieces other than dice, i.e., slices, stew chunks, etc., and to other root crops and vegetables.

The development of simpler methods for estimating the crude fat content of potato chips, frozen French fried potatoes and other commercial fried potato products will be completed.

A follow-up will be made to ascertain the success that processors are encountering in the determinations of SO_2 in fresh potatoes and potato flakes. Modifications of the recommended procedures will be developed if they prove necessary.

The study will be continued on the mode of action whereby glycerol mono-palmitate improves the mealiness of mashed potatoes reconstituted from flakes.

In after-cooking discoloration, investigations will be made of the total acidity and of the individual acids of the stem-end and bud-end tissue. Greater emphasis in the future will be placed on determinations of the iron content and of the polyphenoloxidase potency of potato juice, using methods improved by recent EU research.

The work at WU on potato granules without add-back will be continued and extended to larger, pilot-scale operations to establish engineering feasibility of the processes that have been developed.

Publications: Potato Flakes. A New Form of Dehydrated Mashed Potatoes. IV. Effects of Cooling after Precooking. James Cording, Jr., John F. Sullivan and Roderick K. Eskew. ARS-73-25, July 1959.

Potato Flakes. Roderick K. Eskew, 1960. Potato Handbook 5:28-30. The Potato Association of America, New Brunswick, N. J.

Loss of BHA and BHT During Potato Flake Production. Victor J. Filipic, James Cording, Jr., and Clyde L. Ogg. CA-E-24, May 1960, USDA, ARS, EURDD, Philadelphia, Pennsylvania.

Vitamins in Potato Flakes. James Cording, Jr. CA-E-25, USDA, ARS, EURDD, Philadelphia, Pennsylvania.

Study of Fruit and Vegetable Processing Waste Disposal Methods in the Eastern Region. W. W. Eckenfelder, Jr., Charles F. Woodward, John F. Lawler and Robert J. Spinna, September 1958, Manhattan College, New York, N.Y.

A Rapid Method for the Determination of Sulphur Dioxide in Sulphited Prepeeled Potatoes. L. R. Ross and R. H. Treadway. American Potato Journal 37: 102-107, 1960.

A Rapid Method for the Determination of Sulphur Dioxide in Sulphited Potato Flakes. L. R. Ross and R. H. Treadway. CA-E-23, April 1960, USDA, ARS, EURDD, Philadelphia, Pennsylvania.

Non-food Outlets for Potatoes: Starch and Feed. R. H. Treadway. 1960. Potato Handbook, pp. 45-49.

Effects of Glycerolmonostearate on Reconstituted Potato Granules. W. O. Harrington, R. L. Olson, and Marvel-Dare Nutting. Amer. Potato Jour. 37 (5), 160-165 (1960).

Effect of Certain Area of Production and Storage on Chipping Quality, Chemical Composition, and Specific Gravity of California Potatoes. M. Yamaguchi, B. J. Hoyle, F. W. Zink, W. O. Harrington, and C. E. Hendel. Amer. Soc. for Hort. Sci. Proceedings. 74, 649-660 (1959).

Direct Process for Producing Potato Granules. CA-74-6 (1960) WURDD, USDA, Albany, California.

Research Needs of the Potato Industry. C. E. Hendel. Potato Chipper 18 (11), 70-71 (1959).

An Improved Microscopic Method for Counting Ruptured Cells in Dehydrated Potato Products. R. M. Reeve and G. K. Notter. Food Tech. 13 (10) 574-577 (1959).

6. DETERIORATION DURING PROCESSING

WU

Problem: Oxidative deterioration of potato granules and other dry potato products can be fairly well controlled by packing in the absence of oxygen, but packaging costs could be very substantially reduced if a process could be developed to make potato products resistant to oxidation when packed in air.

Program: A continuing program of basic research involving one professional, industry-sponsored man-year per year, is being conducted with the support of the Instant Potato Granule Manufacturers Association.

Progress: Oxidation of Fatty Acids. Twelve fatty acids were identified from the lipids of dehydrated Russet Burbank potatoes. Linoleic, linolenic, palmitic, and stearic acids were found in the greatest abundance.

The oxidative deterioration of linoleic and linolenic acids in potato granules was followed. The degree of degradation of these acids was found to be well correlated with the degree of off-flavor of the granules, when prepared for serving, and with the volume of oxygen absorbed from the headspace of closed containers.

Identification of Carbonyls. Chromatographic procedures were developed with which the following oxidation products from potato granules were isolated and identified: n-hexanal (85% of the total), 2-octenal, n-pentanal, propionaldehyde, acetaldehyde, acrolein, iso-pentanal, n-heptanal, iso-octanal, n-octanal, and iso-nonanal. An additional 7 compounds were shown to be present.

The method for analyzing for BHT, an antioxidant commonly used to prevent oxidation in stored dehydrated potatoes, has been improved by elimination of interference from compounds developed during storage of potato products.

Plans: The investigations will be continued at the present level, directed toward further isolation and characterization of constituents of dehydrated potatoes that are involved in oxidative deterioration of the product. Further attempts will be made to develop a chemical method suitable for measurement and ultimate use in control of oxidative deterioration.

III. MARKETING RESEARCH

A. Market Potentials, Preferences, and Development

1. CONSUMER DISCRIMINATION AND PREFERENCES FOR POTATO PRODUCTS

MD

Problem: Information on consumers' reactions to potato products and their patterns of purchase and use--and the reasons behind them--is essential background material for efforts to maintain and expand markets. By providing data on preferences, buying behavior, intentions, attitudes, knowledge, habits, and opinions of new potato products or variations in product characteristics, consumer surveys assist the industry in planning effective marketing and promotional programs.

Program: Work in the current year has been devoted to a contract study of consumer discrimination and preference for frozen french fried potatoes by National Analysts, Inc., of Philadelphia, Pa. Less than one professional Federal man-year is utilized annually.

Progress: Field work has been completed and coding is in progress on a study designed to determine the extent of consumer discrimination and preference among four groups of frozen french-fried potatoes, varying in the amount of slivers and irregular pieces. The study was conducted using a panel of household in Pittsburgh, Pa. over a 4-week period, and the findings are expected to provide information to assist the Department in deciding on a possible grade standard revision for french-fried potatoes.

Plans: Analysis of these data will be completed early in 1961. A final report on the project is planned for publication later that year which will complete the work in this area.

2. MARKET POTENTIALS FOR NEW AND IMPROVED POTATO PRODUCTS

MD

Problem: Information on consumer acceptance of new and improved potato products and the sales impact they have on the total potato market are needed to help accelerate the commercial development of potato products by producers and processors, expand the market, and maximize demand for potatoes.

Program: The program is designed to test and evaluate new products in the marketplace, conducted for the most part in collaboration with the four regional utilization laboratories of the Agricultural Research Service. This year's program was carried out in cooperation with the EURDD. About one professional Federal man-year annually is involved in this work at the present time.

Progress: The research objective of the work is to determine the present and potential penetration of dehydrated mashed potatoes and frozen french fries. In Philadelphia, New Orleans, Oakland, and Milwaukee, sales of dehydrated mashed potatoes have been audited in several supermarkets to determine the extent of penetration of the household market by various forms of dehydrated mashed potatoes. In addition, institutional users and suppliers of processed potatoes have been interviewed in Philadelphia.

Plans: The results of the completed phase of this work will be published during the current fiscal year. If necessary, work with particular emphasis on institutional use of processed products, similar to that done in Philadelphia, will be done in one or two large metropolitan areas. These analyses of additional markets will be complementary to the work in Philadelphia and will provide a basis for comparing interregional differences in market penetration by processed potato products.

B. Measurement and Evaluation of Market Quality

3. OBJECTIVE MEASUREMENT OF MARKET QUALITY FACTORS

MQ

Program: No active work this year.

Publications: A non-destructive technique for detecting internal discoloration in potatoes. G. S. Birth. Amer. Pot. Jour. 37: 53-60. Feb. 1960.

C. Product Protection during Marketing.

4. POSTHARVEST PHYSIOLOGY AND STORAGE

MQ, CR

Problem: There is need to develop improved methods of handling and storage of potatoes for the prevention of bruising, sprouting, and other wastage so as to insure potatoes of suitable quality for the various specialized uses to be made of them.

Program: This continuing long-term program of basic and applied research is conducted in cooperation with the Transportation and Facilities Research Division, the Red River Valley Potato Grower's Association, and the Minnesota, North Dakota, and Maine Experiment Stations. The work is conducted in the Red River Valley, Maine, and Beltsville, Maryland and involves about two professional Federal man-years annually, plus a contract with the Medical College of Virginia, Richmond, to study the toxicity of CIPC.

Progress: Control of sprouting with CIPC. In cooperation with Agronomy Department of the University of Maine, small lots of tubers were treated with CIPC. An aerosol of CIPC gave fair to good control of sprouting. Residue analysis conducted by the company supplying the chemical, indicated residues ranging from 0.7 to 1.0 p.p.m. when potatoes were treated in bushel boxes. A commercial application of aerosol CIPC was made to a bin containing approximately 1,000 barrels of potatoes. Conditions for application were poor because of leakage from all parts of the bin. The air duct under the bin was quite small and considerable soil was mixed with the tubers resulting in poor circulation within the pile. Residues on samples taken approximately two weeks after application indicated 15.4 p.p.m. at the middle top of the bin and residues of 0.5 p.p.m. at the front bottom of the bin.

Aerosol CIPC application to a bulk car load of sized potatoes indicated good control of sprouting throughout the load. The highest CIPC residue was 2.8 p.p.m. at the top of one end of the car; all other residues were less than 0.5 p.p.m. Tests to determine whether residues remain after treatment with CIPC due to absorption of the material by the bin walls indicated that there appears to be some residual effect.

Approximately 4,000 bu. of Red Pontiac potatoes in a bulk bin in the Red River Valley were treated with CIPC at the rate of 1.7 gram per bushel of potatoes by volatilizing the chemical with Freon into the storage space. Some sprout inhibition was obtained, but it was not complete or uniform. The presence of a rather large quantity of soil in the potatoes and a lack of through air circulation was probably the cause of the poor distribution of the chemical.

Further tests at Beltsville on the effects of CIPC on suberin and periderm development substantiated a preceding report that dipping of Katahdin potato slices in suspensions containing 25 to 50 p.p.m. delayed periderm formation. Concentrations of 50 to 1250 p.p.m. completely inhibited periderm formation and significantly retarded suberin development. Slices dipped in suspension containing 1250 p.p.m. then held 7 days at 60°F. before inoculation with Erwinia carotovora rotted more readily than inoculated untreated slices.

Toxicity studies with CIPC. The feeding of CIPC in the diets of rats for two years and of beagle dogs for one year at concentrations of .02, 0.2, and 2.0% caused possible effects only in the animals receiving the 2.0% diet. Histopathologic findings showed no lesions that appeared definitely relatable in kind or frequency to any of the feeding treatments.

Copies of the final report of this contract study were given to The National Potato Council and the Potato Chip Institute, the organizations that originally requested the toxicity study. They in turn, submitted the data to a chemical company interested in manufacturing the chemical which petitioned for establishment of a tolerance for use as a sprout inhibitor. The Food and Drug Administration has now established a tolerance of 50 p.p.m. of CIPC on potatoes for sprout inhibition purposes.

Storage and Chipping Quality of Early-Crop Potatoes. Tests with Irish Cobbler potatoes grown at Beltsville and harvested in late summer indicate that short holding periods of 1 to 8 days at 32° or 40°F. initiates a reaction causing the production of dark colored chips and that the reaction continues rapidly with an intensification of the dark color after the potatoes are removed to 70° for 1 to 7 days. Sugar analyses showed that the first sugar accumulation was in the sucrose fraction followed by an increase in reducing sugar content. The data obtained in 1959 indicate again that early crop potatoes must be kept at temperatures near or slightly above 70° if satisfactory chipping quality is to be maintained for much over 10 days and that reconditioning to a satisfactory color is extremely difficult if not impossible.

Storage and Chipping Quality of New Varieties. Of the 13 potato varieties harvested at 2 different locations in the Red River Valley, all except Waseca from Baker, Minnesota made satisfactory chips at harvest. Chips of outstanding color were obtained from the Plymouth variety from both locations. In addition, Cherokee and Tawa from Baker, Minnesota, and Dazoc, Kennebec, and ND 3324-2 from Grand Forks, N. Dak. made chips of outstanding color.

After several months' storage at 55°F., 8 of the varieties from Grand Forks and only 4 from Baker made chips of satisfactory color. Chips of outstanding color were obtained with Kennebec and Plymouth from Grand Forks.

Following storage at about 40° F. for several months and reconditioning at 80° for 3 weeks, none of the varieties from Baker and only Kennebec from Grand Forks produced chips of satisfactory color although Plymouth from the latter location was almost acceptable.

The dormant period of Norland and Redbake at 55° F. was about 2 weeks shorter and that of Boone about 4 weeks longer than that of such standard varieties as Irish Cobbler, Kennebec, and Red Pontiac.

Ventilation rate on keeping quality (Maine). Studies on the effect of different air flow rates on keeping quality of potatoes affected by late blight, freezing and to two different types of bruising were continued. Results indicated the greatest loss from disease development and total weight loss occurred in the bin receiving the lowest air flow and least loss occurred in the bin receiving the highest air flow rates (1½ cfm per barrel). More soft rot developed in the bin receiving no air circulation than in the other bins. A bin with a combination of through and shell ventilation showed an intermediate amount of soft rot and weight loss. These data were consistent with those of the previous two years which indicated that the greatest percentage of marketable tubers was obtained in bins having through ventilation rates of 1 and 1½ cfm per barrel.

Storage in Pallet boxes (Maine). Samples containing frozen tubers showed slightly less weight loss after about 4 months storage in pallet boxes than in bulk storage. However, there was little or no difference in storage rot in the two systems. Potatoes in the pallet bins were cooled more rapidly than those in a deep bin but also were more subject to minor changes in temperature in the storage house.

Washing before storage. Pre-storage washing of pallet bin lots of potatoes in Maine was continued because of the interest of water separation of potatoes from rocks in harvesting. Considerably more minor lenticle infection developed in washed potatoes than in unwashed ones during 5 months storage in a commercial type storage. Moderate lenticel infection was about the same in tubers which had been left wet as in tubers which had been sponge-dried prior to storage. Minor lenticel infection was much more severe in tubers which were irrigated excessively during the growing season, than in tubers grown under more normal conditions. Moderate lenticel infection was about the same in both treatments.

Plans: The toxicity studies of CIPC has been completed but additional studies on methods of application will be made. Particular emphasis will be placed on the velocity of air flow necessary to get the desired penetration throughout a bin of potatoes. Studies will also be made on residual effects and comparison of CIPC with MENA for table stock potatoes during the latter part of the season. No further work on storage and chipping quality of new varieties is planned but the work on storage and chipping quality of new varieties will be continued another year. Studies on ventilation methods and rates will be continued. Pre-storage washing studies will be continued another season. CR is continuing work with CIPC and nonyl alcohol on stored seed potatoes.

Publications: Effect of fertilizer on the chipping quality of freshly harvested and stored Red River Valley Potatoes. H. Findlen. Amer. Potato Journal 37:85-89. March 1960.

C. Product Protection During Marketing.

5. POSTHARVEST DISEASES.

MQ

Problem: Better methods of control are needed for physiological and pathological disorders of potatoes which result in unsatisfactory quality or excessive wastage during storage, transit, and marketing.'

Program: A continuing long-term program involving basic studies on the nature of temperature induced pathological changes in potatoes and applied research on the control of both physiological and pathological disorders with studies conducted at field laboratories in Maine, Minnesota, and California, at market laboratories in Chicago and New York City and at Beltsville, and involving this past year less than one professional Federal man-year.

Progress: Internal Black Spot. California- Research at the University of California has shown that potatoes surrounded by an atmosphere enriched with CO₂ are more susceptible to black spot than those in normal atmospheres. This finding and the high incidence of black spot following the wet spring of 1958 suggested that poor aeration might increase susceptibility to black spot. Potatoes were, therefore, submerged in water for various lengths of time and then bruised. There were no consistent differences in the severity of black spot among the treatments or controls at either 50°F. or 77°F., after 22 to 46 hours of immersion, or between tubers bruised immediately upon removal from water or 24 hours later.

Maine- Internal black spot was sporadic in Maine this past season, and was apparent only in occasional lots of tubers. Pressure bruising without internal discoloration appeared to be worse in some lots of potatoes examined, but little or no correlation could be noted between the severity of pressure bruising and the incidence of internal discoloration. Tubers held in a storage bin showed a slightly greater incidence of internal discoloration as the depth from the top of the bin increased. However, this increase was relatively slight (8% at 4 foot depth, 11% at 8 foot depth).

Plans: Internal black spot studies will be continued. An attempt will be made to develop a method of forecasting susceptibility to black spot. Work on the effects of preharvest conditions on storage decay, will be initiated in Maine.

Publications: Pressure Bruises and Internal Black spot of Maine Potatoes. H. V. Toko. Maine Farm Research 7 (1) :17-20. 1959.

C.. Product Quality During Marketing.

6. MAINTAINING QUALITY DURING TRANSIT

MQ

Problem: With the adoption of new types of rail and truck equipment and the use of heavier loads and faster rail schedules, there is need for study of methods of loading and protective services under these changing conditions for

the varied needs of potatoes for chips, seed, and table use during the seasonal extremes of winter and summer shipping periods.

Program: A continuing program involving studies on icing and ventilation services, heater placement, load heights and load patterns, and on evaluating new and improved truck and rail equipment for obtaining desirable transit temperatures and protection from bruising or other damage in transit. Different aspects of this broad study are under way at the Fresno, California; East Grand Forks, Minnesota; Beltsville, Md; Presque Isle, Maine, and in the southeastern States in cooperation with Transportation and Facilities Research Division, Crops Research Division, ARS, potato shippers and receivers, and the railroad and trucking industry, and involves about two professional Federal man-years annually.

Progress: Handling and Transit Refrigeration of California Potatoes.

A protective service that would result in transit temperatures between 60 and 70°F. is considered most desirable for early crop chipping potatoes. Shipping over northern routes from California to Chicago under standard ventilation was adequate for most of the shipping season from May 15 to July 15. During periods of hot weather when initial tuber temperatures were over 90°F., initial icing of 1 to 2 tons in each bunker removed the field heat without danger of excessive chilling. Keeping the car ventilators closed during the first 3 days was an economical and practical way of obtaining suitable temperature with outside air and preventing the buildup of excessive humidity and heat in the cars after the initial ice supply was melted.

A comparison of floor layer bruising in railway cars was made in hand-stacked vs. "bump"-loaded 100 lb. bags. No consistent difference in bruising occurred with the two methods of loading.

Heavy loads (50,000 pounds) were compared with conventional loads (43,000 pounds) of potatoes shipped from the San Joaquin Valley. No consistent difference occurred in amount or severity of bruising in transit. Increasing the load to 50,000 pounds would reduce the required number of rail cars by about 16 percent and the heavy load should lead to a reduction in shipping costs.

When Whit Rose potatoes in 100-lb. bags were car-precooled with bunker ice for 4 hours, the average initial pulp temperature (6 tests) of 78°F. was reduced at the rate of 2.6° per hour. The average air blast temperature was 57°.

Bulk Rail Shipments - Maine. Studies were initiated on shipments of potatoes in a newly developed bulk rail car with built-in conveyors. Little if any additional bruising occurred during transit in the two cars shipped this season. Total weight of potatoes in the two cars was approximately 62,000 pounds and 69,000 pounds respectively. CIPC aerosol treatment of the tubers in the car appeared to give satisfactory control of sprouting.

Icing late potatoes from Maine. Pre-icing of cars prior to loading prevented potato temperatures from rising during a 3-to-4 day transit period in late spring. Re-icing after 24 to 30 hours reduced tuber temperatures 4 to 7 degrees below loading temperature. Non-iced cars shipped with vents open showed considerable fluctuation in tuber temperatures at the top of the load.

Shipment of precut seed from Maine. Two test shipments of pre-cut seed were made. Cars were held on track prior to shipment for a 2-day period with heaters set at 55°F. and fans operating. After 24 hours temperatures within the load were all above 50°, and within 48 hours were above 55°. Heaters were removed and the seed shipped to destination. Temperatures during transit of one of the cars moving to Pennsylvania ranged between 55° and 60° during the first 5½ days. On arrival after approximately 9 days seed piece temperatures were 61°, 62° and 68° for the bottom, middle and top quarter length. Air temperatures at doorway positions were 67° on the bottom and 68° on top. No spotted bags were found in the load. Less than 1 percent severe decay was present in experimental samples on arrival and after 1 week at 70°.

Yields from precut seed. Precut Irish Cobbler seed pieces planted at Beltsville almost immediately after transit in 1959 produced approximately the same yields as fresh cut seed, and significantly higher yields than uncut "B" size potatoes. They also produced significantly higher yields than precut seed stored 6 weeks after transit at 40°, 45°, 50°, or 60°F. before planting.

Precut seed pieces of Kennebec stored at 40° or 50°F. for 10 days, 5 and 7 months gave approximately the same yields. They also did not differ significantly in yield from fresh cut or uncut "B" size tubers.

The length of storage at 40° or 50° had no consistent effect on yields from precut Pungo or Sebago seed pieces, but seed pieces stored at 40° usually outyielded those stored at 50°.

Effect of Temperature near Freezing on Seed Potatoes. Entire carloads of seed potatoes have been rejected as unsuitable for seed purposes when only a few bags in the car showed freezing damage because receivers felt that even the potatoes in bags without freezing damage were unsuitable for seed. If unwarranted, this rejection places an unfair burden on shippers and carriers. If justified, protective practices can be adopted by shippers that will provide temperatures well above freezing. Research was initiated to determine the effects of freezing and near freezing temperatures on Katahdin, Irish Cobbler, Red Pontiac and Pungo seed potatoes obtained from Maine and the Red River Valley. Potatoes were stored at 40°F. at Beltsville, Md., before treatment. Treatments were: (1) Storage at 40° only, (2) Storage at 40° with 1 day at 30°, (3) Storage at 40° with 10 days at 30°, (4) Storage at 40° with 1 day at 25° handled gently (to permit undercooling with a minimum of freezing, and (5) Storage at 40° with 1 day at 25° handled roughly. Following treatment potatoes were held 2 weeks at 50° prior to cutting and planting in Delaware, New York, and Maine. Potatoes with severe freezing damage were discarded.

Potatoes in treatments 1, 2, and 3 emerged somewhat faster than those in treatments 4 and 5. Differences were not marked and final emergence counts averaged above 95 percent for all treatments.

Shipping Tests from the Red River Valley. Transit temperature of both table-stock and chipping potatoes moving by rail to Chicago during the winter in cars with thermostatically controlled alcohol heaters were much more uniform in the Cargotemp car in which the fans operated continuously than in the conventional car in which the fans operated only when the car was moving.

Chipping potatoes handled and shipped by truck from the Red River Valley to Kansas City, Mo. sustained less mechanical injury when handled in 1-ton boxes than in 100-lb. bags.

In a preliminary rail test shipment, slightly less bruising of bottom layer potatoes occurred in 50-lb. single-wall corrugated fiber-board boxes than in 100-lb. burlap bags. When stacked only 4 layers high the boxes withstood transit well.

Hydrocooling and Packaging Early Potatoes. Three paired rail shipping tests of hydrocooled and non-hydrocooled potatoes packed in both polyethylene and vent-view paper bags were conducted from Foley, Ala., to Chicago, Ill. Two tests were of Lasoda variety and one of Pontiac. No decay was evident on arrival and only a small amount developed during the 7-day holding period at 70°F. Of the small amount of decay which developed, more was evident in hydrocooled lots than in the non-hydrocooled ones. Two to 3 times as much decay developed in poly bags as in the vent-view paper bags. The amount of feathering or skinning was also increased by hydrocooling and/or packaging in polyethylene. Due to the fact that decay was unusually light, it is not known what the effect of hydrocooling and packaging in poly would be during a high decay (wet) season.

Preliminary tests with chemicals for control of soft rot indicated that of many tried, only two formulations showed any promise.

Plans: Studies with precut seed potatoes are largely completed and a final report will be prepared. The California studies on transit refrigeration of chip potatoes, method of loading and heavy loads will be prepared for publication. Additional studies on containers are planned from California and the Red River Valley. The Maine test shipments will be continued. The studies on the effects of low temperature on seed and on hydrocooling and packaging early potatoes will be continued at least 1 more year.

Publications: Waxing potatoes -- its effect on weight loss, shriveling, decay and appearance. R. E. Hardenburg, H. Findlen, & H. W. Hruschka. Amer. Potato Jour. 36: 434-443. December 1959.

Protective Services for Chipping Potatoes Shipped from Kern County, California. John M. Harvey. Potato Growers Assn. of Calif. and Ariz. 1960 Yearbook. pp.110-112.

D. Transportation, Storage and Packaging

7. IMPROVED LOADING METHODS FOR 50- AND 100-POUND BAGS

TF

Problem: Increasing freight, protective service, and labor costs, mounting losses from spoilage, damage and reduced shelf life because of ineffective refrigeration and ventilation during transportation have resulted in substantial losses to shippers, receivers, and carriers and greatly increased marketing costs for potatoes in recent years. More efficient loading methods that can be used with little or no additional cost to shippers can provide better protection for containers and products, facilitate better refrigeration and ventilation during transit, more efficient preshipment and post-shipment handling methods and more effective use of available loading space in the transportation vehicles, leading to reduced per-package transportation refrigeration, and handling costs.

Program: This long-term study involves test shipments by rail and truck from various producing areas throughout the country to different terminal markets to develop and test new loading patterns, load securing equipment, measurement of container and product damage, air velocity, temperature differentials, and labor requirements for loading and unloading. It is carried out from Washington, D. C. and Orlando, Fla., with the informal cooperation of shippers, receivers, railroads, truck lines, container and loading equipment manufacturers, state experiment stations and other interested groups and involves about one professional Federal man-years annually.

Progress: Truck Shipments: Preliminary research begun during the 1959 shipping season for late summer potatoes from New Jersey to Florida markets, resulted in the development of a new "air flow" loading pattern for truck shipments of 50-pound paper bags. The new loading method provides for eight continuous channels extending the entire length of the load for improved air circulation to almost every bag in the trailer. Measurements of air velocity in each of the channels in the shipments moving under ventilation showed a sufficient rate of air flow through the load to effectively help in the removal of heat and moisture from the bags during transit. The new loading method can be used with little or no loss of load capacity in average highway trailers at no additional costs to the shipper or trucker.

Rail shipments: A new method of manipulation of the ventilation openings in the bunker bulkheads of refrigerator cars to improve air circulation through ventilated shipments of potatoes and other commodities was successfully tested with dummy loads during the past year. However, no test shipments of potatoes using this forced air circulation method have yet been made.

Plans: Additional tests of the new loading pattern for truck shipments of 50-pound paper bags will be made during the 1960 shipping season for late summer crop potatoes from New Jersey to southern markets. Emphasis will be placed on determining the adequacy of the number and location of ventilation openings in the bags to insure getting the best cooling results from the new loading pattern. Test shipments by rail using the new forced air circulation in ventilated shipments in refrigerator cars are planned for the coming year.

Publications: New Stacking Method Cuts Potato Spoilage. Russell H. Hinds, Jr. USDA, Agricultural Marketing, May 1960.

8. PACKAGING POTATOES AT POINT OF PRODUCTION

TF

Problem: More and more retailers prefer to sell prepackaged potatoes the year around because of lower labor costs and smaller waste and spoilage losses. Prepackaging at point of production has many inherent advantages. However, shippers of early varieties are reluctant to prepackage because these varieties are extremely perishable.'

Program: This long range program of research to determine the commercial feasibility of prepackaging perishable varieties of potatoes is being conducted in California and the Southeastern states in cooperation with growers, shippers, and receivers. The work involves less than one Federal professional man-year.

Progress: Successful conclusion of work to prepackage and ship California White Rose potatoes was reported to the Committee at its last meeting. Since then a publication has been prepared and issued. The potatoes were prepackaged in 10-pound paper bags with mesh windows and in 10-pound polyethylene bags and shipped from Kern County to eastern markets. The total cost of materials, labor, and transportation--regardless of which bag was used--was about \$2.55 per 100 pounds. This compared to about \$2.20 for bulk potatoes shipped in 100-pound burlap bags. All the potatoes arrived in good condition.

At the request of a group of growers, researchers this year shifted their packaging studies to Alabama which makes heavy shipments of Lasoda potatoes, another perishable early variety. Added to the two 10-pound packages tested the year before, were two 5-pound bags, one of 1½mil polyethylene film and one of polyethylene net.

The poly net bag, a very recent development, reached the researchers so late it was included in only 4 of 14 test shipments to northern markets.. Therefore, its performance could not be compared directly with that of the other containers, although it showed considerable promise and greatly interested the potato shippers and receivers who saw it. The conventional 50-pound burlap bags carried the potatoes to market in good condition.

Although there were no substantial differences in the amount of skinning, researchers at terminal markets found that potatoes in the experimental containers sustained considerably less total bruising than the potatoes in the burlap bags:

	<u>Percent bruising</u>
10-lb. poly film bag	1.8
5-lb. poly film bag	2.2
10-lb. paper bag with mesh window	2.8
50-lb. burlap bag	8.1

Potatoes in half the shipments were hydrocooled, than packaged; and in half the shipments they were packaged, then precooled in rail cars. In all containers except the paper bags with mesh windows there was slightly more decay among the wetted potatoes in the hydrocooled shipments than among the drier potatoes in the precooled shipments:

	Percent decay	
	Hydrocooled	Precooled
10-lb. poly film bag	1.1	0.8
5-lb. poly film bag	0.9	0.7
10-lb. paper bag with mesh window	0.2	0.3
50-lb. burlap bag	0.5	0.1

Greening was very minor and did not prove to be a problem. The potatoes in this year's harvest made the highest quality crop in many years.

Plans: The test will be continued next season to determine the ability of the consumer packages to carry an average crop of early potatoes to market.

Publications: Prepackaging Early California Potatoes at Point of Production. Peter G. Chapogas and Philip W. Hale. USDA, Marketing Research Report No. 401, June, 1960.

E. Equipment, Facilities, Methods and Firm Efficiency

9. IMPROVED METHODS, EQUIPMENT, PLANT LAYOUT AND DESIGN FOR HANDLING, PACKING, AND STORING POTATOES. TF,FS

Problem: More efficient work methods, techniques, devices, and equipment, and improved facility designs are needed for the handling, storage, and preparation for market of potatoes at concentration and shipping points in order to minimize labor requirements and storage losses.

Program: A long-term program involving engineering-economic research to develop more efficient handling, storing, and packing methods, techniques and equipment, and to design improved facilities; carried on at the Red River Valley Potato Research Center, East Grand Forks, Minnesota; the Maine Potato Research Center, Presque Isle, Maine; and a field office at Gainesville, Florida; in both laboratory and commercially-owned facilities in North Dakota, Minnesota, Maine, and Florida; in cooperation with the North Dakota, Minnesota, Maine, and Florida Agricultural Experiment Stations, the Red River Valley Potato Growers' Association, the Market Quality Research Division, the Marketing Economics Research Division, the Harvesting and Farm Processing Branch, Agricultural Engineering Research Division of ARS, and the Forest Products Laboratory of the Forest Service, at a current rate of about five professional Federal man-years annually.

Progress: Handling, Storing, and Packing the Mid-Western Fall Crop. At the Red River Valley Potato Research Center the manuscript, "Ventilating Potato Storages in the Fall Crop Area," was revised. Further editing was done on the manuscripts, "Handling Potatoes into Red River Valley Storages--Methods and Equipment," and "The Development of Pallet Boxes for Potatoes."

The development of improved bulk handling of potatoes and environmental regulation in large storage bins was started in 1958-59 by filling an 18' x 38' x 18' deep bin with uncleaned field-run potatoes by means of an overhead track-supported 40-foot through-belt conveyor. First results with this method did not give the small temperature range wanted. Therefore, the tests were continued by filling the bin with uncleaned field-run potatoes but moving the conveyor by means of a traveling crane-support. This eliminated the market wedge of soil under the conveyor; still the potato temperature ranged from 34° to 44° as late as January. Since a smaller temperature difference is needed for good storage, a tilt-belt cleaner and high capacity sizer was built for tests during the 1960-61 season. With this equipment, cleaned and sized potatoes will be placed into the large bins at harvest to determine whether cleaning and sizing will permit better temperature regulation and to determine the value of sizing potatoes before storage.

The use of a sheet of polyethylene as a bin divider was tested. It was laid on angle-of-repose of one lot of Cobbler potatoes in back of a bin and covered with a lot of Pontiacs in front. There was no significant difference in temperature of the potatoes in the test bin compared with those in an adjoining bin. The Pontiacs were removed easily at the end of storage period without mixing them with the Cobblers. A sheet of polyethylene also was laid on the inclined pile of a partly emptied potato bin and refrigerated air was circulated through a wall air space over the polyethylene and back to the refrigeration coils. It was hoped that this simple method would maintain a higher humidity around the potatoes than in the circulation air but, due to leakage through the wall space and the edges of the polyethylene, no difference in vapor pressure was secured.

Studies and analysis of data were continued on labor and equipment costs for moving potatoes from storage to packing lines for the purpose of comparing labor and equipment costs for various types of storages using flumes, conveyors, elevators and hand forking for bulk potatoes and forklift truck handling of potatoes in pallet boxes.

Field studies were conducted and a comparative cost analysis made of labor, equipment, materials, freight, space, injury losses and truck tie-up time in packing, loading, transporting, processor handling, and temporary storage of potatoes in 100-pound burlap bags and in one-ton capacity collapsible returnable pallet boxes. A manuscript entitled, "Handling and Shipping Potatoes for Processing in Pallet Boxes and Burlap Sacks," was prepared for publication.

Work has been started on developing detailed plans for four general storage types with two or three variations for each type. These plans are being developed to be included in a general potato storage report which will include recommendations regarding construction techniques, layout and design, air circulation and ventilation systems, insulation, building materials, etc. These plans will be developed around up-to-date handling systems and methods.

During the report period assistance on problems associated with storage construction and regulation, and handling, and equipment was provided by project personnel stationed at the Center to approximately 300 firms and individuals from 18 states and 5 foreign countries.

Handling, Storing, and Packing the Eastern Fall Crop. At the Maine Potato Handling Center, work was continued on development and organization of data for a manuscript on "Handling Potatoes from Storage to Packing Line." This includes comparison of the several basic methods used at typical operating rates in Maine.

Studies of the packingline were started with simultaneous work sampling and time study techniques, covering some of the sonsumer package types and sizes and a limited number of the many variations of equipment, facilities, layouts, and methods in present use.

Preliminary studies were made of the newly developed conveyORIZED refrigerated railroad car for the bulk shipment of potatoes to determine labor and equipment requirements and costs for loading and unloading this car. Results of the initial tests indicate that more than 600 hundredweight can be loaded in this car with a minimum amount of injury and a definite cost saving compared to shipment in 100 lb. bags.

Storing the Northeastern Late Summer Crop. Work in this area was confined to editing the manuscript, "Comparative Methods of Cooling Long Island Potato Storages," for Department publication.

Handling and Packing the Southeastern Spring Crop. Time study data were obtained and preliminary productive time values were developed for powered trucks equipped with clamp fixture and for hand clamp trucks used in receiving potatoes in field boxes.

Bulk receiving methods were studied and, in an effort to develop an improved method, tests were conducted in which potatoes were dumped as a load from a wooden baffle-equipped dump truck body directly onto a concrete floor. This method was tried with the hope that it might replace the more costly self-unloading bulk-hopper body trucks and necessary temporary holding bins, both of which are expensive special units that have no other practical use during the year.

Preliminary observations indicate that regular dump trucks could be substituted for the special bulk body trucks and that potatoes could be dumped directly onto a concrete floor with no appreciable change in potato damage. Time studies indicated that, under commercial operating conditions, it would take about 0.42 man-minute per 1000 lbs. to unload with the dump truck as compared to about 1.33 man-minutes per 1000 lbs. with the bulk body truck.

Additional time study and work sampling data were obtained on receiving potatoes in sacks and manually carrying to and dumping the potatoes from sacks into a holding bin, and on using a conveyor between the field truck and the bin with the workers remaining on the truck and emptying the sacks onto the conveyor.

Pallet Design: Work at the Forest Products Laboratory to obtain fundamental data relative to pallet design and manufacture for use by shippers and manufacturers, and for development of a rational method of pallet design, included a number of studies that, while not directly involving potatoes, will aid in resolving broad problems in use of pallet containers that may apply also to use for potatoes. These included development of a method for calculating the load-carrying capacity of top deck boards of three-stringer general-purpose pallets and incorporation into a simple circular calculator; determination by test of the desirable construction features of apple harvesting wood bin pallets which showed that for 10 styles tested in simulated weathering and rough-handling three performed well, four were acceptable, and three failed in test. It appeared that vertical sideboards, rather than large triangular corner posts, and many assembly nails are desirable features. In cooperation with AMS, eight designs of pallet boxes for shipping apples and citrus fruits to market in bulk were reviewed and changes proposed. A Wood Pallet Promotion Clinic was held in September, 1959. In connection with studies of manufacture and use of thick-sliced veneer, a potato bin made from 7/16-inch red oak veneer was placed in use in a potato chip factory. The bin is in good condition after several months use.

Plans: At the Red River Valley Potato Research Center studies will be completed and data analyzed on labor and equipment costs for moving potatoes from storage bins to the packing line. A report covering this work will be prepared and submitted for publication.

Tests will be conducted with the tilt-belt cleaner and high-capacity sizer to determine the effect on maintaining potato temperature during storage and the value of sizing potatoes before storage. Six 500 cwt. capacity deep bins will be used in these tests. Four of the bins will be filled with cleaned and sized potatoes with each filled with a different size ($1\frac{1}{2}$ to 2 inches, 2 to 3 inches, $2\frac{1}{2}$ to $3\frac{1}{2}$ inches, and $3\frac{1}{2}$ inches and up). The fifth bin will be filled with cleaned potatoes but not sized (field-run). The sixth bin will be filled with uncleaned field-run potatoes which will serve as a check for the tests. In addition, two 5,000 cwt. capacity bins will be filled with cleaned potatoes overlapping small and large size potatoes. Results with these two bins will be compared with that of earlier years.

Time studies and cost analysis will be made of labor, equipment, materials, freight, space, injury losses and truck tie-up time in packing, loading transporting, and processor handling and temporary storage of potatoes by various methods in bulk and semi-trailer trucks.

A manuscript tentatively titled, "Fall Crop Potato Storage and Handling," will be completed, incorporating recommendations on potato storage and structures. A number of detailed plans will be included as guides for persons anticipating the construction of new potato storages.

At the Maine Potato Handling Research Center, work sampling studies of packing line operations will be continued to obtain data on additional equipment and package types. Studies will be made of bin filling using experimental equipment. Additional time studies will be made of loading and unloading the conveyORIZED railroad car for bulk shipment. The manuscript on "Handling from Storage to Packing Line" will be completed.

The manuscript, "Comparative Methods of Cooling Long Island Potato Storages," will be completed and published.

At the Gainesville, Florida, field office, work will be continued for at least one more year on the comparison of powered trucks versus hand clamp trucks for receiving and handling potatoes in field boxes at the packinghouse.

Further experiments will be conducted with the bulk-dump-onto-floor method of handling potatoes. Arrangements for moving the potatoes by water from the dumping point to the main flume leading to the packing line will be tried and data on injury, labor requirements, and other factors will be obtained.

Pallet boxes will be studied to determine their suitability for handling potatoes from the field to the packing line, including temporary holding of the potatoes.

Improved methods for filling, weighing, and closing 50- and 100-pound burlap bags and 50-pound paper bags, suitable for the relatively short packing season in the area, will be sought.

Comparative data including labor and equipment inputs and unit costs which reflect equipment and facilities predominant in the Hastings area for representative packinghouse systems for receiving, handling, and temporarily holding potatoes will be developed. Effort also will be directed toward finding practical means for increasing sorting efficiency.

The Forest Products Laboratory plans to conduct simulated weathering and rough handling tests on at least 2 more of each of 10 styles of wood bin pallets, including effects of water-repellent treatments. Observation and participation in shipping tests of apples and citrus fruits in bulk will be continued, along with design of realistic tests to simulate the stresses and impacts of actual use. This should lead to useful information applicable to similar commodities. Effort will be made to develop a lateral-impact test for pallet fasteners that will simulate stresses imposed by ordinary rough handling, and compare pallet joints made with machine-driven nails to those made with hand-driven nails.

Publications:

Bin Pallets for Agricultural Products. T. B. Heebink. FPL Report No. 2115, June 1958.

Load-Carrying Capacity of Deck Boards for General-Purpose Pallets. T. B. Heebink. FPL Report No. 2153, August 1959.

Preservatives for Wood Pallets. J. O. Blew, Jr. FPL Report No. 2166, October 1959.

A Light-Weight Conveyor for Filling Deep-Bin Potato Storages. R. S. Claycomb and Herbert Findlem. USDA, AMS-362. February 1960.

A Clamp for Potato Sacks. Leonard Pawski and Albert Dubuque. USDA, Agricultural Marketing, Nov. 1959.

Pressures on Walls of Potato Storage Bins. Alfred D. Edgar. USDA, AMS-401. Aug. 1960.

Conveyor for Potato Storages. Alfred D. Edgar. USDA, Agricultural Marketing. May 1960.

Storage of Fall-Harvested Potatoes in the Northeastern Late Summer Crop Area. A. H. Bennett, R. L. Sawyer, L. L. Boyd, and R. C. Cetas. USDA, MRR No. 370. Jan. 1960.

Mechanized Methods of Receiving Potatoes at Maine Trackside Storages. Edward F. Johnston and Earl K. Bowman. Maine Agricultural Experiment Station Bulletin 585. Sept. 1959.

Use of Weather Bureau Records in the Design of Farm Buildings. A. H. Bennett and L. L. Boyd. Presented at the 1959 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, Dec. 15-18, 1959. Paper No. 59-819 (Mimeo).

F. Costs, Margins, and Organizations of the Marketing System

10. MARKETING COSTS AND MARGINS FOR POTATOES

ME

Problem: Provide information on the marketing costs and margins for potatoes from various producing areas sold in several major markets and analyze the factors affecting packinghouse costs to indicate possible methods of reducing costs.

Program: The studying of marketing costs and margins for potatoes is a part of an overall continuing program of work on marketing costs and margins conducted at the direction of Congress. It requires about one man-year per year of professional Federal labor.

Progress: The costs of two methods of filling and weighing 100-pound and 50-pound bags of early crop potatoes in Florida and Alabama were compared. In the lowest-cost method, the scales are built into the filling station, permitting one work to both fill and weigh the bags. Costs were higher when the two jobs were separated. In handling 100- and 50-pound bags from packing to loading, the handtruck method of transportation had lower costs in most situations, when loading both rail cars and trucks, as compared with conveyor systems. However, when only trucks are loaded, handling patterns are simplified and conveyor systems had lower costs at average to high volume levels. For fall potatoes sold in Atlanta, Chicago, Los Angeles, and New York City during the 1955-56 thru 1958-59 seasons, farm prices varied sharply from season to season. The marketing margin was higher for Idaho Russets than for other varieties of fall potatoes sold in each of the four cities during the four seasons, and was lowest for Long Island Katahdin-Chippewa type potatoes sold in New York City during each season. The marketing margin ranged from a low of \$3.13 per hundredweight for Long Island Katahdin-Chippewa type potatoes sold in New York City during the 1955-56 season to a high of \$7.47 per hundredweight for Idaho Russets sold in New York City during the 1958-59 season. California growers received greater returns than growers in other producing areas, but no single producing area had the lowest grower returns in all years.

Plans: The packinghouse efficiency work in the Southeast has been completed. Data on marketing margins for potatoes will be compiled on a

continuing basis.

Publications: Marketing Margins for Fall Potatoes, John K. Hanes, USDA, MRR. 1960.

11. COMPETITION IN THE PROCESSED POTATO MARKET

ME

Problem: The rapid growth of the processing market for potatoes is causing many adjustment problems for producers and fresh market distributors, as well as processors. This study will provide an understanding of the competitive position of the major potato producing areas in the market for processed products to assist producers and marketing firms in making these adjustments.

Program: This is a three-year cooperative research project with the Idaho Agricultural Experiment Station using less than one man-year per year of Federal professional labor.

Progress: In single-product plants the costs of processing 100-pounds of field-run potatoes (except in the case of flour where lower grades are used) are as follows:

Frozen French fries	\$1.24
Dehydrated diced or cubes	.91
Flakes	.89
Granules	.87
Flour	.62

These costs include all direct inputs except the raw product, but exclude interest, transportation, and selling costs. They represent cost levels which efficiently operated plants in most part of the country can achieve with the best technology available. Multiple-product plants can achieve some reduction in costs below these by combining products, particularly where frozen French fries, granules or flour are included. Packaging costs range from a high of 9 cents per pound of finished product for flakes in retail packages to a low of $3\frac{1}{2}$ cents per pound of granules in institutional packages.

Plans: A report on processing costs will be published during the coming year. Work will continue to add other cost elements between the processor and the consumer in order to analyze the competition between regions in producing and marketing processed potato products, and the impacts of continued growth in the processing market on the potato industry.

12. CHANGES IN METHODS OF MARKETING

ME

Problem: Potato industry leaders need more accurate information on the changes taking place in wholesale markets for fruits and vegetables to evaluate the impacts of these changes on the potato industry and to assist in making decisions and recommendations for adjustments to meet these changes.

Program: A 3- to 4-year research program involving about four professional Federal man-years annually, in cooperation with the Agricultural Experiment Stations in Wisconsin, West Virginia, Kentucky, Maine, Montana, Nebraska, New York, Utah, New Mexico, Louisiana, Arkansas, South Carolina, Oklahoma, and Minnesota, and through contract studies in the San Francisco market area by the University of California, Berkeley, California, and in the Pittsburgh market by Midwest Research Institute, Kansas City, Missouri.

Progress: A study of chainstore merchandising and procurement practices found that direct buying by corporate and voluntary chainstores has increased markedly in the postwar years as many more chains grew to a size which made it attractive to them. It can be expected to continue to increase as other corporate and voluntary chains grow to this size. This will mean an increased demand for more uniform products. The size of the lot purchased by individual organizations will increase, on the average. It will be increasingly difficult to dispose of variable lots, small lots, and lots of odd size, grade, color, etc. This may mean increasing emphasis on large packing and shipping operations which can put up uniform lots which will meet the specifications of some part of the chainstore market. Markets may tend to become more segmented, as more direct buyers line up a small number of shippers with whom they deal regularly. Volume control will become more important, as the market for supplies which cannot be sold to direct buyers shrinks, and the effect of each additional carload added to or withdrawn from this market will become more pronounced. Wide swings in supply may cause wider swings in price than formerly and it will be more difficult to clean up supplies in a market because the number of buyers will have declined.

Fieldwork has been completed for a study of the present status and organization of 52 wholesale fruit and vegetable markets throughout the country. This information will provide the basis for description of the structure of wholesale markets and an analysis of the role of terminal markets in the years ahead.

Plans: This work will be substantially completed during the coming year with completion of the analysis and publication of the findings.

Publications: Chainstore Merchandising and Procurement Practices. The Changing Retail Market for Fresh Fruits and Vegetables. William E. Folz and Alden C. Manchester, USDA Marketing Research Report No. 417, July 1960.

G. Price, Supply, and Consumption

13.. PRICE, SUPPLY, DEMAND, AND OUTLOOK ANALYSIS FOR POTATOES

AEC

Problem: To facilitate more orderly production and marketing of potatoes, growers, processors, and handlers need more information about forces which influence the supply, demand, price and utilization of the crop.

Program: A continuing long-term program of basic economic research relating to supply response, supply, demand, price and consumption relationships, and a continuing appraisal of the current and prospective economic situation for potatoes, involving one Federal man-year annually.

Progress: Market situation and outlook work was continued during the past year. Frequent appraisals were made on the current and prospective short-term situation as to supply, demand, price, and consumption of potatoes. Results of such appraisals were published in quarterly issues of the "Vegetable Situation" and the "National Food Situation," and brief reviews in monthly issues of the "Demand and Price Situation." Basic statistical series were maintained and extended.

Supply relationships for winter and early spring potatoes and for the late spring crop were developed. In contrast to other seasonal potato crops, acreage of winter and early spring potatoes trended upward during the last decade. Analysis indicates that demand for potatoes for chipping was an important factor in the expanding acreage. Price received by growers for potatoes in the previous year was also an important factor.

The acreage of late spring potatoes, which trended down during the 10-year period, appears to be importantly affected by previous year's price and previous year's acreage. Of these, previous year's acreage, which to some extent reflects all past prices, was the most important factor influencing late spring plantings. These results are in accord with those reported earlier for the late summer and fall potato crops.

Some further work was done on factors influencing total potato consumption. In addition to retail price which was the most important factor influencing consumption, the highest previous level of income, and degree of urbanization were also inversely related to consumption.

Plans: Continuing analysis and reviews will be made on the short-term market situations and outlook for potatoes. The work on the present program of supply, demand, consumption and price analysis of seasonal potato crops will be completed and a manuscript prepared.

Publications: What Makes Potato Prices? Olman Hee. Presented at the annual meeting of the National Potato Council, at Chicago, Illinois, November 17, 1959. (USDA Mimeo).

The Role of Expectations in Agricultural Supply Relationships. Olman Hee. Presented at the Agricultural Sciences Section, Virginia Academy of Science, Richmond, Virginia, May 13, 1960. (USDA Mimeo).

The Vegetable Situation, AMS, Washington, D. C. (Quarterly).

The National Food Situation, AMS, Washington, D. C. (Quarterly).

The Demand and Price Situation, AMS, Washington, D. C. (Monthly).

14. FOREIGN TRADE IN POTATOES

Problem: The United States is the net exporter of potatoes. The principal importing countries are Canada, Cuba, Mexico, and Venezuela. Seed potatoes are shipped to Cuba, Venezuela, Argentina, and Uruguay. The Latin American countries normally plant small whole seed, and it is a problem for our growers to select a sufficient supply of small sized seed at harvest time to fill these orders.

Program: A long-term program is continuing to appraise and develop a demand for both seed and table potatoes in the Latin American countries. This primarily involves notifying U. S. suppliers of trade opportunities. This involves less than one man-year and will be carried out in cooperation with the Agricultural Attaches and trade groups.

Progress: Exports of potatoes during the past season have been well above recent years. Trade opportunities in Venezuela, Argentina, and Uruguay and Cuba have been called to the attention of the U. S. potato industry. Canada continues to be the largest market for U. S. potatoes and there are no trade problems with them.

Plans: It is planned to make some experimental shipments of "cut seed" to some of the Latin American countries. If these shipments are successful, it will eliminate the seed size problem.

